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ABSTRACT

A majority of states are now involved in developing, revising, and implementing state frameworks in mathematics, science, and other core subjects. The Council of Chief State School Officers completed a one-year study of 60 current state curriculum frameworks in mathematics and science. The purposes of this study were to define and describe state mathematics and science curriculum frameworks, evaluate the role of frameworks in systemic reform, and assist states with development of new frameworks. Chapters in this report reflect key aspects of the design of the study, including: (1) a survey of states to identify frameworks and collect information about state context; (2) a content analysis of key elements of the frameworks using definitions and categories developed in the study; and (3) a qualitative review of specific aspects of recent frameworks by teams of experts. The value of frameworks is as follows: one-half of frameworks link content to teacher professional development; frameworks can provide a rationale for use of technology and tools in classrooms; frameworks can help explain an approach to systemic reform; and frameworks can assist schools in evaluating curriculum organization and resources. Appendices include Elements for Analyzing State Curriculum Frameworks, Definitions of Categories and Concepts for Conceptual Mapping of State Frameworks, Questions for a Qualitative Analysis of State Frameworks in Mathematics and Science, and Sample Vignettes. Contains 34 references. (MKR)

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State Curriculum Frameworks

Alternatives in Science

How are They Changing Across the States?

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State Curriculum Frameworks in Mathematics and Science:

How are They Changing Across the States?

May 1995

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Council of Chief State School Officers (CCSSO)

The Council of Chief State School Officers (CCSSO) is a nationwide non-profit organization of the 57 public officials who head departments of public education in every state, the District of Columbia, the Department of Defense Dependents Schools, and five extra-state jurisdictions. CCSSO seeks its members' consensus on major educational issues and expresses their view to civic and professional organizations, federal agencies, to Congress, and to the public. Through its structure of standing and special committees, the Council responds to a broad range of concerns about education and provides leadership on major education issues. The State Education Assessment Center is a permanent, central part of the Council of Chief State School Officers. This Center was established through a resolution by the membership of CCSSO in 1984.

The CCSSO Study of State Curriculum Frameworks in Mathematics and Science was conducted through the cooperation of the state departments of education. The study report is intended for use by state policymakers, developers of curriculum frameworks and education standards, science and mathematics educators, professional education organizations, and federal agencies. The study was supported by a grant from the National Science Foundation, Division of Research, Evaluation, and Dissemination of the Education and Human Resources Directorate. The views or conclusions expressed in the report do not necessarily reflect the position of the National Science Foundation.

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We were fortunate to receive expert advice and assistance at several key points in the study. Experts in science and mathematics education and research from across the U.S. provided a solid foundation for the study in guiding our study design. Teams of experts met for several days to review and analyze frameworks, and to identify issues for framework development. These individuals willingly provided time and expertise and worked together to reach consensus on complex issues.

State science and mathematics supervisors were very cooperative in providing copies of their frameworks and related state documents, responding to survey questions, and reviewing study drafts. The study would not have been possible without the timely cooperation of professional staff in all of the states.

The Council was assisted in conducting the study by staff of three organizations. Researchers at Policy Studies Associates, Washington, DC, worked on the content analysis of frameworks; science experts at the National Center for Improving Science Education, Washington, DC, provided advice on the analysis design; and we collaborated with the frameworks evaluation team at SRI International, Menlo Park, CA, in selecting the study's expert panel and developing a set of key elements for analysis and reporting on frameworks. In addition, Doug Archbald, University of Delaware, consulted with us on the frameworks content analysis.

State Curriculum Frameworks in Mathematics and Science: How are They Changing Across the States?

Executive Summary

The Council of Chief State School Officers (CCSSO) has completed a one-year study of current state curriculum frameworks in mathematics and science. The Council study was a response to the interest in frameworks that many educators have expressed. A majority of states are now involved in developing, revising, and implementing state frameworks in mathematics, science, and other core subjects. National and state initiatives towards systemic education reform are centered on high content standards for the education of all students, and many people view state curriculum frameworks as an effective way to communicate standards. Local educators are redesigning curriculum and instruction to meet the challenge of high standards in science and mathematics for all students.

The purposes of the study were to define and describe state mathematics and science curriculum frameworks, evaluate the role of frameworks in systemic reform, and assist states with development of new frameworks. All state education agencies were asked to voluntarily submit their mathematics and science frameworks, and those received by CCSSO by August 1994 were included in the study. The study design included three components: (1) a survey of states to identify frameworks and collect information about state context; (2) a content analysis of key elements of the frameworks using definitions and categories developed in the study; and (3) a qualitative review of specific aspects of recent frameworks by teams of experts. The study was supported by a grant from the National Science Foundation.

Current Status of State Frameworks

The CCSSO study found that the concept of a state curriculum framework is changing and that state frameworks vary widely among states. A majority of states are developing or have recently completed new frameworks in mathematics and science. Ongoing national, state, and local efforts to improve and reform mathematics and science education are linked to state frameworks. The report gives a snapshot of the contents, purposes, and organization of frameworks as of 1994; and excerpts from recent documents show how frameworks are developing and changing.

From the Council's survey of all states, the District of Columbia, and Puerto Rico, the status of frameworks at the end of 1994 can be summarized as follows:

- **States developing frameworks.** In 1994, new frameworks were being developed by 21 states in mathematics and 25 states were developing science frameworks. Four states were developing a framework that addresses mathematics, science, and other subjects.

- **Recent frameworks completed.** From 1990 to 1994, 16 states completed frameworks in mathematics and 16 states completed frameworks in science. Eight states completed a framework that includes a combination of subjects.

State Context

CCSSO's study covered 60 frameworks in mathematics and science—40 frameworks completed from 1990 to 1994, and 20 frameworks completed in 1990 or earlier. Interviews were conducted with state science and mathematics supervisors in 28 states. The following findings on state context apply to frameworks completed since 1990.

- **Purposes**: Three main purposes were reported for recent mathematics and science frameworks—to provide higher standards for mathematics/science education or assist local educators to meet higher standards (60 percent of frameworks); to guide local reform of mathematics or science education (45 percent); and to assist with developing local curriculum (35 percent).

- **State mandates**: Over 70 percent of frameworks since 1990 were developed based on a mandate from the legislature or the state board of education.

- **Intended users**: Teachers were defined as primary users in 80 percent of recent frameworks, and 75 percent defined curriculum developers as primary users. Local administrators or board members were defined as primary users in 50 percent of frameworks.

- **Funding**: All frameworks had funding support from states. Federal funds, through the Eisenhower Mathematics and Science Program, aided development of 40 percent of frameworks since 1990. Private, corporate support assisted with 5 percent of recent frameworks.

- **Steps in development**: Key steps used in development of recent frameworks were as follows—expert panel for design and review; review of national standards, reports, and other state frameworks; teachers involved in writing; successive drafts reviewed; and wide dissemination.

- **Context defines frameworks structure**: Due to differences in state context and purpose, all frameworks differ in organization, structure, and elements that are included. Some states have more than one document in a subject area.

Content of Frameworks

The following findings are based on content analysis of 60 frameworks using a common set of elements for analyzing and describing frameworks. The elements represent a set of hypotheses about effective state frameworks, and the findings are initial evidence and patterns across the states.

- **Vision for mathematics/science education**: All 60 state frameworks analyzed in the study include a section giving the state's vision for mathematics or science education or rationale for the framework. Recent frameworks typically quote or cite national standards or reports as a part of the vision and rationale.

- **Framework as comprehensive resource**: In recent mathematics and science frameworks, content standards often comprise one section of the framework, and other sections provide educators with explanation and suggestions for application to curriculum development, assessment, teaching practices, and use of materials.

- **Content statements or standards**: All frameworks have statements (or "standards") that define and recommend subject content. However, the scope and structure of content statements differ markedly. A number of recent frameworks have content statements that cut across grades K-12 or are written by grade cluster (e.g., 5-8). Fewer recent frameworks provide content statements by grade (elementary) or course (secondary).

- **Organization of content**: Recent frameworks in mathematics show a high degree of consistency with the main content emphases of the NCTM Standards, and recommend content categories (or "strands") that connect content across grade levels. The main headings of the most recent science frameworks are generally consistent with the content structure in AAAS Benchmarks and the draft NRC Science Education Standards. Recent frameworks in mathematics and science include process skills or emphases in learning, e.g., problem solving, reasoning, communication, and scientific inquiry, as an integral part of the mathematics or science "content."

- **Communication of content**: State frameworks are changing from simply outlining intended content toward assisting educators with developing and implementing content through explanations, examples, and models. Among the 40 frameworks completed since 1990, 50 percent provide examples or models that illustrate application of content in classrooms; only 10 percent of frameworks prior to 1990 provided any examples. Diagrams, graphics, or photographs are used in 60 percent of recent frameworks; in 33 percent of older frameworks.

- **Pedagogy**: Twenty-five percent of recent frameworks provide detailed, contextualized examples of teaching practices and discussion of classroom implementation; 50 percent of recent frameworks outline or list possible teaching practices in a content area; and 25 percent focus only on content and do not try to address pedagogy. The teaching practices most frequently described in recent frameworks are: (a) use of active, hands-on lessons; (b) using tools and technology; (c) conducting experiments and investigations; (d) writing and graphing; and (e) assessment strategies.

- **Equity in curriculum**: Recent frameworks provide few specifics on how to address equity in curriculum. Eighty percent of recent frameworks address race/ethnic and gender equity concerns in the vision or rationale statement, but only 50 percent provide even one strategy or suggested practice for increasing equity in how curriculum is implemented.

Frameworks and Education Reform

The CCSSO study analyzed the role of frameworks in mathematics and science reform in states. Linkages between recommended subject content and state and district policies were identified in the content analysis, and science and mathematics supervisors were interviewed about dissemination of frameworks within the states.

- **Policy linkages**: The vision statements of recent frameworks typically indicate that the framework should have a role in mathematics or science education reform. But, only 55 percent of recent frameworks outline any connections between the recommended mathematics or science content and change in education policies regarding student assessment programs, teacher professional

development, teacher education, or selection of materials and textbooks. One-half of recent frameworks link content with state assessments. Among older frameworks, only 15 percent of frameworks have one or more policy linkages.

- **Dissemination**: The main target groups for providing copies of recent frameworks were: schools (60 percent of frameworks), curriculum specialists at district-level or department heads in schools (40 percent), district administrators (40 percent), and teachers (35 percent). Professional development with frameworks was offered in all states, but the sessions varied from increasing awareness of the framework to specific training on implementation of framework concepts in classrooms.

Issues for Framework Development

Following is a summary of issues that were identified by expert review teams from qualitative review of 23 recent frameworks. The issues are based on a consensus of the experts forming the teams. They do *not* represent a view of "one best way" to develop state frameworks, but rather are intended for use by states as they make decisions about organization and presentation of frameworks.

Standards set expectations for students. The review teams found that frameworks differ in the degree to which standards statements and language are consistent with the expectations that national standards are establishing for students. Some frameworks include standards statements that ask for only a low level of cognition, such as "know types of fossils," as opposed to a statement such as "conduct investigation to identify and explain differences in fossils." Content standards are less useful when they are written simply as a checklist of content topics to be covered or presented to students.

Clarity and consistency in language are important. The level and style of writing, use of graphics, and organization and format of the framework should be appropriate for the intended audiences. How the framework is organized and presented can be a key factor in initially inviting use of the framework and in readers returning to the document for further use.

Content standards have certain positive attributes.

- Standards clearly specify content to be learned and expected skill or capacity with content.
- High expectations for student learning for all students are set by content standards.
- Standards should specify the appropriate developmental level for expected knowledge and skills, matched to students' grade range.
- The range of content standards should recommend a challenging curriculum, including higher-order skills.
- The language and format of standards should encourage understanding and use by educators and be written with sufficient detail to be useful in developing local curriculum.

Mathematics content needs consistency to detail level. Recent state frameworks show high agreement with emphases of NCTM curriculum standards. Below the major headings and categories for content, mathematics frameworks varied in how consistently the specific content topics or sub-headings followed their own vision statement and NCTM Standards. For example, state recommendations toward problem solving and communication were sometimes not well connected to content areas such as geometry or measurement. The emphasis in NCTM standards on problem solving, connections, and conceptual understandings are typically more clearly expressed for grades K-4 and 5-8, than for grades 9-12 where traditional approaches to content tend to remain.

Science frameworks differ from national standards in several areas. The majority of science frameworks reviewed by expert teams were written prior to the publication of the AAAS Benchmarks or the draft NRC Science Standards, and states had a less well-defined set of guidelines to use in developing their frameworks' standards, as compared to mathematics. Some states left out or gave less emphasis to key content areas that AAAS and NRC eventually included— nature of science, history of science, science as inquiry, science and society, and science applications.

Framework components should have a consistent approach. The review teams viewed internal consistency as a key ingredient of frameworks—for example, if a framework's vision for mathematics calls for integrating content across the grades, then the framework's recommended content strands or standards at different grade levels should be consistent in recommending integrated math content. Suggested curriculum development strategies should follow the same ideas to help demonstrate how a strand is developed.

Examples help to demonstrate intended content. The review teams noted that the use of examples, vignettes, and strategies allows the framework to make the vision and content recommendations concrete and explicit. They also provide the educator with a fuller understanding of the underlying approach to content and instruction.

Instructional emphasis and student skills can be interwoven with content. The review teams found that state frameworks show marked progress in expanding beyond a basic skills emphasis to instructional emphasis on higher order skills for all students in mathematics and science, such as expecting students to apply knowledge through problem solving, reasoning, communication, or scientific inquiry. When these emphases are modeled through concrete suggestions, examples, and alternative practices, they reflect the new vision more effectively than when desired skills are presented as lists or objectives separate from content.

Frameworks show a need for strategies on equity in curriculum. The main equity issue in mathematics and science curriculum, largely not addressed in state frameworks, is the substantial differences in the content that is actually taught to all students, and how the curriculum differs by the race/ethnicity or gender of students. The review teams found that recent frameworks all include a statement on the need for greater equity in mathematics and science education in the rationale or vision section, but a consistent weakness of frameworks is the lack of presentation of strategies and practices that promote equity. Equity needs to be woven through the frameworks in a self-conscious way.

Content can be linked to assessment. State frameworks often recommend that classroom assessment be designed for consistency with content standards, but the review teams found only a few frameworks that provide models or examples of assessment exercises that exemplify standards. Recent frameworks generally recommend alternative assessment strategies for classrooms that are consistent with content standards, but typically they do not provide a strong link to reform of state assessment programs. There appear to be inconsistencies between framework content recommendations and the design of some required state assessments.

Frameworks should address the use of technology and tools in classrooms. Availability and appropriate use of high technology, such as calculators and computers, and other tools for doing mathematics and science, such as rulers, scales, mathematics manipulatives, or laboratory equipment, should be addressed in state frameworks. An approach taken in one mathematics framework is a discussion of traditional, alternative, and recommended classroom uses of calculators and manipulatives.

State Curriculum Frameworks in Mathematics and Science: How are They Changing Across the States?

Introduction: Reporting Change in State Frameworks

State curriculum frameworks are gaining increasing attention at state, national, and local levels of the education system. Most states are now involved in developing, revising, and implementing state frameworks in mathematics, science, and other core subjects. Current national initiatives toward systemic education reform are centered on high content standards for education of all students, and state curriculum frameworks are the vehicle for communicating the standards. Local educators who are asked to use state curriculum frameworks to write and plan curriculum want to see how they will be useful for improving teaching, learning, and assessment.

In 1994, the Council of Chief State School Officers (CCSSO) undertook a year-long study of state frameworks in mathematics and science. The main purposes of the study were to define and describe current state curriculum frameworks, evaluate the role of frameworks in systemic reform, and assist with the development of frameworks.

This report summarizes recent practices in developing frameworks and identifies the range of existing state subject or content-related documents, including curriculum "guides," "objectives," "content standards," or "frameworks." The report gives the results of a descriptive content analysis of frameworks and a qualitative review of recent frameworks by expert teams. The study is supported by a grant from the National Science Foundation (NSF), Division of Research, Evaluation and Dissemination, in the Directorate for Education and Human Resources.

Renewed Involvement of States with Curriculum Frameworks

State boards of education and state education agencies have renewed their activity in developing, revising, and disseminating curriculum frameworks and other documents related to subject content. Two predominant trends have prompted recent state involvement with frameworks: the increasing role of states in education reform, and the involvement of states in developing and implementing national professional standards for mathematics education and science education.

State Policies and Frameworks

State curriculum frameworks are undergoing a process of change and redefinition as states continue to define their policy-making and leadership role in education. The state policy initiatives of the 1980s focused on raising basic requirements for elementary and secondary education, including increases in graduation requirements, higher teacher-certification standards, new state assessment programs, and higher teacher pay (Blank and Espenshade, 1988). The combined policy changes produced a stronger state role in education, increased the states' funding responsibility for education, and raised the authority of the state for accountability of schools, teachers, and local districts (National Governors' Association, 1986).

Very shortly, educators began debating the effects of the policy changes. People raised questions about the effects of top-down policy initiatives in changing how schools and classrooms are organized and whether these initiatives were having any real effect on the curriculum that is actually taught (Firestone, Fuhrman, & Kirst, 1989; Fuhrman, Clune, & Elmore, 1988; Smith & O'Day, 1991). Research analysis found that state policy changes may have increased the time spent on core academic subjects and improved students' basic skills, but that teaching and learning of higher-order thinking skills were not advanced (Clune et al., 1989; ETS Policy Information Center, 1990; Porter, 1994). A "second wave" of education reforms in the late 1980s moved away from state policy initiatives toward more decentralized change, including efforts toward the professionalization of teaching (Carnegie Forum on Education and the Economy, 1986) and "restructuring" schools through site-based management and changing staff roles (Wohlstetter & Mohrman, 1994).

State education agencies also reexamined their role in defining curriculum and instruction for schools. In a few states, elementary and secondary curriculum had been defined at the state level for many years through a state course syllabus, such as in New York with the state Regents courses, and in others, such as Alabama and North Carolina, through state "courses of study" that outlined content areas in academic secondary courses. Course syllabuses outlined content to be learned, but did not attempt to reflect advances in the discipline, connecting themes, or pedagogy and classroom practices. Another role of states in curriculum was in writing and publishing curriculum guidelines that provided suggestions for teaching, materials, and classroom activities, such as in Connecticut, Iowa, Wisconsin, and Oregon.

State Assessments

With the rapid implementation of state-mandated student competency tests and norm-referenced achievement tests in the late '70s and '80s, states such as Illinois, Florida, Texas, Georgia, and Louisiana published state curriculum objectives for specific grade levels and subjects (Curry, 1992). The objectives defined the content for tests and tended to shape instruction of students to prepare for the tests (Baker & Stites, 1991; Haertel, 1989). State tests emphasized basic skills, particularly in lower grades, with movement toward some higher-order skills in upper grades and advanced courses (Romberg, 1990). A CCSSO survey of states in 1987 showed that in mathematics, 38 states had a state curriculum guide or objectives for mathematics and 38 states had a guide or objectives for science, whereas 40 states had a state achievement or competency test in mathematics and 27 had a state test in science (Blank & Espenshade, 1988).

In the 1990s, state policymakers are advocating changes in assessment programs to incorporate more "authentic" methods of testing that will meet several goals, including accountability, closer links to curriculum, and assisting instruction. Many states are trying to design, pilot, and implement new assessment methods (McDonnell, 1994).

Mathematics and Science Standards

With the publication of the National Council of Teachers of Mathematics (NCTM) *Curriculum and Evaluation Standards for School Mathematics* (1989), states experienced a new round of activity with state curriculum frameworks. The NCTM *Standards* were completed after several years of drafting, review, comment, and revision, involving educators and mathematicians at all levels; and states worked on ways to represent the *Standards* in state frameworks. Some states, such as Alabama, Arizona, Michigan, Minnesota, and Tennessee, produced outcomes-based documents that were designed to reflect

the NCTM *Standards* by recommending a broader range of content at all grade levels and emphasizing higher-order skills in mathematics. California took a more comprehensive approach to a state framework for mathematics education by establishing demanding content standards for three grade clusters, as well as suggesting instructional examples, activities, materials and technology, and assessment exercises for implementing content in schools. In 1992, 41 states reported to CCSSO that mathematics frameworks had been revised or developed, or were planned "in response to the NCTM standards" (Blank & Dalkilic, 1992).

State frameworks in science have had similar functions and structure as in mathematics. Until recently, science frameworks were organized and differentiated by discipline or subject (e.g., biological/life, physical, and earth sciences); and many state documents called "courses of study" focused on secondary science. Since the late 1980s, several influential reports from professional organizations have recommended significant reforms in science education. In 1989, the American Association for the Advancement of Science (AAAS) published *Science for All Americans*, which defined science literacy of high school graduates in terms of key content knowledge and skills and identified common themes across science disciplines. The AAAS' *Benchmarks for Science Literacy* (1993) described content knowledge and skills expected of students at specific grade levels. The National Science Teachers Association's (NSTA) recommendations on *Scope, Sequence, and Coordination* (1993) outlined a secondary science framework that integrates the disciplines. Discussions and drafts leading to the *National Science Education Standards* being published by the National Research Council (NRC) of the National Academy of Sciences (draft, 1994) reflect the science education reforms in some states and are being used by states in developing new frameworks.

Consistent with recommendations from national science organizations, state science frameworks recently have placed more emphasis on science skills and integration of science disciplines. For example, frameworks from California (1990), Florida (1993), and Nebraska (1994) provide new approaches to developing science themes across subjects, integrating science processes with content, and providing explanatory text for the recommended science content.

Two of the organizing principles of the NCTM *Mathematics Standards* and the draft NRC *Science Education Standards* are clustering standards for mathematics by three grade levels (K-4, 5-8, 9-12) and linking content across grades and clusters with common mathematics/science content strands and instructional emphases. These approaches clearly distinguish a set of standards or a framework from an actual curriculum at the district or school level.

National Goals

Current work on state frameworks has been influenced by other reports and studies. The term *curriculum framework* has been recently used in national and international studies that are aimed at broad analysis of curriculum across schools, districts, states, or countries. A 1988 report recommending indicators for K-12 science and mathematics education discussed the role of a curriculum framework to analyze and report on differences in curriculum content at state or local levels, including variation in both the intended curriculum and the implemented curriculum (Murnane & Raizen, 1988). The Third International Mathematics and Science Study (TIMSS) is based on mathematics and science frameworks that were developed by international consensus among scientists, mathematicians, educators, and researchers from participating countries (Robitaille et al., 1993). The National Assessment of Educational Progress (NAEP) is now written and con-

ducted based on a content framework (e.g., reading, mathematics, science, U.S. history, geography, etc.) that is developed by a consensus panel of subject experts, educators, and researchers (CCSSO, 1991; National Assessment Governing Board, 1994). The frameworks developed for these studies all outline recommended content areas with varying levels of detail, as well as desired student skills, capacities, or perspectives with the subject content.

In 1991, the U.S. Congress and the National Education Goals Panel (NEGP) created the National Council on Education Standards and Testing (NCEST) to consider the question of establishing national education standards in the United States to support national goals 3 and 4 concerning student achievement in core academic subjects. The NCEST 1992 report, *Raising Standards for American Education*, recommended that development of academic standards for K-12 education was desirable and feasible. The U.S. Department of Education awarded grants to support the consensus process and the writing and production of standards in six core subjects, including science. Several types of education standards were outlined in the NCEST report—content standards, performance standards, delivery standards (now called *opportunity-to-learn* standards), and assessment standards. These concepts and definitions became central to the Goals 2000 legislation approved in 1994, which establishes federal support for voluntary state-based systemic reform that includes development and implementation of high academic standards.

Many groups have made efforts to define education standards and place them into operation. A Task Force of the National Education Goals Panel helped define "high standards for American students," as stated in the goals, and set some criteria for review of standards (NEGP, 1993). Currently, states are working on their state plans for systemic reform under the guidance of a broad-based state committee. A priority responsibility for each state is defining how the state will address standards for core subjects. Professional education organizations are helping to define and establish content and performance standards. In addition to the work of NCTM in mathematics and the science organizations mentioned previously, a publication of the American Federation of Teachers discusses why standards are needed—as well as criteria for good standards (Gagnon, 1994; Shanker, 1994). CCSSO recently produced a report for the Goals Panel that recommended criteria of good education standards and processes for reviewing and responding to state standards (CCSSO, 1995).

Purposes of CCSSO Study of Frameworks

CCSSO began a study of state curriculum frameworks in mathematics and science in fall 1994 under a grant from NSF. The study is responding to several kinds of interests in analyzing the current status, characteristics, and content of mathematics and science frameworks.

Define and Describe State Frameworks and Standards

Considering the history of states' roles with curriculum and education policies, definitions of a "state framework" vary. It is apparent that the concept of a curriculum framework and the needs of states for a framework-type document are changing. State and national officials, educators, and researchers are interested in the current status and description of state curriculum frameworks, including what state frameworks have in common and how they differ. Because educators are greatly interested in frameworks and content standards, the study addresses the basic question of how a framework is de-

fined and what is included. The relationship among national standards, frameworks, and state standards is a key question.

Many states have already revised and written curriculum frameworks or standards in mathematics in response to the NCTM standards. The CCSSO study reports on the various approaches. In science, states have contributed to the development of national standards by the NRC, and many states have used the draft standards to begin work on developing or revising state frameworks in science. States have also used recommendations for science education reform in AAAS' *Science for All Americans* and *Benchmarks*, NSTA's *Scope, Sequence, and Coordination*, and reports from the National Center for Improving Science Education to develop new frameworks. The CCSSO study of frameworks informs states about the implications of the national standards and reports in science for work at the state level, the direction some states have already taken in revising state frameworks, and key issues in frameworks development.

Evaluate the Role of Frameworks in Systemic Reform

The CCSSO study also is directed toward national and state-level interests in examining curriculum frameworks as a link between systemic reform, national content standards, and state standards. Essentially, systemic reform includes ambitious, coherent state education policies, together with professional discretion and decision making in schools (Furhman & Massell, 1992; Smith & O'Day, 1991). Systemic reform plans thus far typically involve linking key principles and concepts in state curriculum frameworks to student assessments, teacher education, professional development, and use of technology.

NSF has a strong interest in the CCSSO study in connection with the Statewide Systemic Initiatives (SSI) program. The SSI program is assisting 24 states and Puerto Rico in planning, designing, and implementing systemic education reform in mathematics and science. Some SSI states have state frameworks or content standards for mathematics or science as a central element of their plans. NSF officials have expressed a need for a picture of current practice with state frameworks, examples of positive approaches to frameworks, and how they are linked to national standards in mathematics and science.

Assist with Development of Frameworks and State Standards

The CCSSO study of frameworks also addresses the interest of the states, NSF, and the U.S. Department of Education in developing and improving frameworks and state standards for mathematics and science. In 1992 and 1993, the national Eisenhower Science-Mathematics program, administered under the Office of Educational Research and Improvement (OERI), awarded grants to 16 states to develop state curriculum frameworks in mathematics and science. The grants are assisting states in writing new curriculum frameworks and linking the framework content to state policies on teacher education, professional development, and student assessment. Some regional mathematics and science education consortia, supported by OERI and housed in the regional research and development laboratories, are assisting with framework development and implementation.

The Goals 2000 legislation established a planning, design, and support process for states to lead systemic reforms based on high standards for subject content and student learning. Goals 2000 provides funding to states to support systemic state reform based on state-developed plans. The legislation calls for state plans to include development and implementation of content standards in core subjects, stu-

dent assessments linked through performance standards, and opportunity-to-learn standards or strategies. The CCSSO study provides baseline information on the range of state documents and approaches to content standards. The study helps to show where states are with standards and frameworks and it provides suggestions and examples for states to consider with their approach to standards.

The CCSSO frameworks study is coordinated with the evaluation of the Eisenhower Math-Science Frameworks projects being conducted for the Department of Education by SRI International. The SRI evaluation is examining the effects of the frameworks grants, over a three-year period, on framework development in the 16 states and their links to assessments, professional development, and teacher certification. CCSSO is also collaborating with a study of the implementation and dissemination of NCTM standards being conducted for NSF and OERI (McLeod, 1994).

Systemic reform is based on both top-down and bottom-up efforts. It now appears that more is expected of state frameworks both in defining expectations from state leaders and in helping local educators understand the rationale and thinking behind new approaches to instruction and learning needed to move students toward the standards. From the viewpoint of states planning systemic reform, a state curriculum framework might be characterized as a "policy lever" that can help to connect various reform activities through referring to common expectations for content and learning and help to provide a common language for educators, policymakers, and the public to discuss the direction for reform.

The CCSSO frameworks report is aimed at assisting states by summarizing current trends across states, identifying different approaches and examples, and highlighting key issues about how frameworks are organized and written. CCSSO does not report or advocate any "one way" that frameworks should be organized, presented, or written.

Key Questions About State Frameworks

As states begin to plan their response to the Goals 2000 initiative, both state leaders and national education officials will be asking whether current state curriculum frameworks or content standards contain the high, challenging standards for what students should know and be able to do that are envisioned in the national goals. Leaders will be looking for plans for attaining these goals through systemic, standards-based reform. More broadly, state and national leaders need basic information on the characteristics of all state frameworks—a reference source that will allow states and others to identify various approaches and models for developing frameworks and specific elements of them. This study attempts to provide this information.

The key questions about frameworks can be grouped into three categories, as follows.

Descriptive Questions

- How many states have state curriculum frameworks (or curriculum-related documents)?
- What do states mean by a curriculum "framework"? What is included?
- Which states are developing curriculum frameworks?

Context Questions

- How is the organization and contents of a framework related to the state context?
- What are different functions or purposes of state frameworks?
- How is the development of curriculum frameworks related to state education policies and to systemic education reform?
- How are frameworks being disseminated and implemented?

Analytical Questions

- How many states have "content standards"? How are content standards addressed?
- What is current "practice" with key elements or components of state frameworks (e.g., vision for reform, themes or strands, and use of examples and vignettes)?
- What are examples of exemplary framework development?
- What are major issues in developing state frameworks?

Chapter 1: Design for Frameworks Analysis

The design for the CCSSO study of state curriculum frameworks had three main components: (1) a survey of states to collect frameworks and interviews to gather information about state context, (2) content analysis of key elements of frameworks using a conceptual mapping methodology, and (3) qualitative review and analysis of frameworks' strengths and weaknesses by review teams of science and mathematics experts.

Descriptive Information from States

Voluntarily responding to our survey, state curriculum leaders submitted state curriculum frameworks, guides, standards, and curriculum-related documents. All state mathematics and science supervisors were contacted by letter in February 1994 and asked to submit their documents using a broad definition of "framework" and to "provide basic information about the framework." Because an objective of the study was to report on similarities and differences among frameworks, the types of documents to be included was purposely broad. As of August 1994, all states, the District of Columbia, and Puerto Rico responded to the request. However, frameworks were not analyzed for every state. Several states asked that their current frameworks not be included in the analysis because they were developing new versions, and some states did not have a framework completed. For each state, only one document was analyzed as "the framework" for mathematics or science. If other curriculum-related documents were submitted or identified by a state, they were reported as "related documents."

To obtain direct information on framework purposes and how they were developed, CCSSO conducted interviews in July 1994 with 28 selected state mathematics and science supervisors. The supervisors were in states with recently completed frameworks; and we selected all SSI states and states funded to design new frameworks by the U.S. Department of Education's Eisenhower Program. The interviews produced information on the purposes, initiation, funding, and dissemination of recently developed frameworks.

Content Analysis of Frameworks

Currently, there are no written theories or body of research on what makes "effective" curriculum frameworks. Few studies have examined the differences in state frameworks and other curriculum documents. This study provides an initial description of how frameworks are organized, what they contain, and how information is presented.

Previous studies of state curriculum frameworks or guides have focused on the relationship of these documents to state policies (Archbald, 1994; Cantlon, Rushcamp, & Freeman, 1991; Massell, 1993; Porter, Archbald, & Tyree, 1991), or they have examined specific curriculum emphases, such as higher-order versus basic skills (Freeman, 1989). Recently, state frameworks have received renewed emphasis in relation to national standards and the state role in systemic educational reform. Recommendations have been made on the role of frameworks and their functions in relation to reform (Curry, 1993; Sutton, et al., 1993; Smith & O'Day, 1991).

The present study analyzes the contents and organization of current frameworks to determine what is meant in states by a "framework" and to identify current trends and practices in the development of frameworks. An important aspect of the analysis is to determine how states define and write content standards in mathematics and science.

The design for analyzing the content of state frameworks was based on 11 "elements for frameworks analysis" selected in January 1994 by consensus of an expert advisory panel of science and mathematics educators, curriculum specialists, and researchers. The elements were defined from panelists' knowledge of national and international standards, research, and reports; review of a sample of recent state frameworks; and knowledge and experience of the panelists. The elements are as follows:

- Status of the framework in state
- Vision of mathematics/science education
- Function and intent of the curriculum framework
- Approach of the framework as a policy statement
- Conception of the curriculum
- Content of mathematics/science in curriculum
- Presentation and communication of the content
- Pedagogy
- Equity in curriculum
- Enabling conditions
- Policy connections or linkages.

The elements were *not* defined or intended as the characteristics of an exemplary framework or as a prescription to follow in framework development. Together, the elements comprise an initial set of hypotheses for studying and describing state frameworks. (See Appendix A for the complete list of elements, further research questions for each element, and a list of the advisory panel members.)

The actual content analysis, or "conceptual mapping," of frameworks was conducted by CCSSO research staff with a subcontractor, Policy Studies Associates (PSA). Based on the panel's recommendations of elements for analysis and preliminary review of a subset of current state frameworks, CCSSO staff wrote a set of definitions, categories, and procedures to standardize the analysis across frameworks. The categories for reporting on frameworks were defined to be inclusive of differences in frameworks across the states. We tried to develop procedures that could be replicated and are practical. The frameworks' rich content and their complexity defy a simple checklist-style analysis. Through concept mapping, however, we were able to reflect significant detail about each framework while creating a process that could be summarized.

We trained research staff in the use of the study definitions and procedures. Two research staff members, working separately, reviewed and coded each framework. A senior staff member arbitrated and resolved differences in results. In total, 60 state mathematics and science frameworks were analyzed in summer 1994 with the conceptual-mapping definitions and procedures. The product was a database that allowed individual framework "maps" to be produced, as well as aggregated matrixes and tables showing patterns across frameworks. We then shared the mapping results with state framework contacts for review and checking. (see Appendix B for definitions of categories and concepts used in the conceptual mapping analysis; Appendix C discusses the qualitative review and analysis of the frameworks; Appendix D lists the frameworks reviewed in the qualitative analysis.)

Qualitative Review and Analysis of Specific Elements

State frameworks are currently undergoing change, and many states are continuing to redefine how they are written and used. Our interests in this study were not simply to know the range of current activity with frameworks, but to also increase understanding of critical issues in how states develop frameworks and what approaches they can take. In other words, the study could provide a summary of current "practices" in developing frameworks.

We decided that a process of framework review by teams of experts would be an effective strategy to begin to identify issues of quality and effectiveness of frameworks. The review was conducted by teams of experts, based on the elements for analysis developed at the outset of the study and the results of the conceptual mapping analysis. Two aspects of the design for the team reviews were critical for the validity of the qualitative analysis: (a) a common set of questions was used by teams to assess specific framework elements; and (b) a three- to four-person team of experts reviewed each framework, and a consensus review formed the basis for identifying general issues across frameworks.

The qualitative analysis did not attempt to rate or compare whole frameworks or to compare frameworks to each other. The analysis assumed that frameworks are developed within differing state contexts, demands, and purposes. We organized the questions guiding the analysis into three themes, based on the elements for frameworks analysis: (1) content of mathematics/science, (2) pedagogy and communication of content, and (3) enabling conditions and policy linkages. The questions formed the basis for written team responses on each framework, including questions such as these:

- Does the framework reflect national mathematics/science standards? Does it reflect the state's vision of mathematics or science curriculum?
- How does the framework contribute to educators' understanding of state or national standards?
- How consistent are the framework's vision and principles for content with the examples and suggestions for implementation?

(See Appendix C for the complete list of qualitative analysis questions and a list of the review team members.)

The teams reviewed and analyzed 23 mathematics and science frameworks (Appendix D). CCSSO used several criteria in selecting the frameworks. The qualitative analysis had to be limited to a number of frameworks that could be reviewed and discussed by four-person teams during a three-day period—the estimate was four frameworks per team. It was important to have face-to-face discussion in the review process, and limits were imposed by costs and time.

The conceptual mapping results showed that the NCTM standards redirected curriculum development and that state mathematics frameworks reflected the organization and style of the NCTM standards. We decided to focus on those completed since 1990. More detailed, qualitative review and analysis of frameworks since 1990 allowed CCSSO to have a sound basis for addressing questions about recent developments with frameworks to provide assistance to states as well as to assess the relationship of systemic initiatives to frameworks.

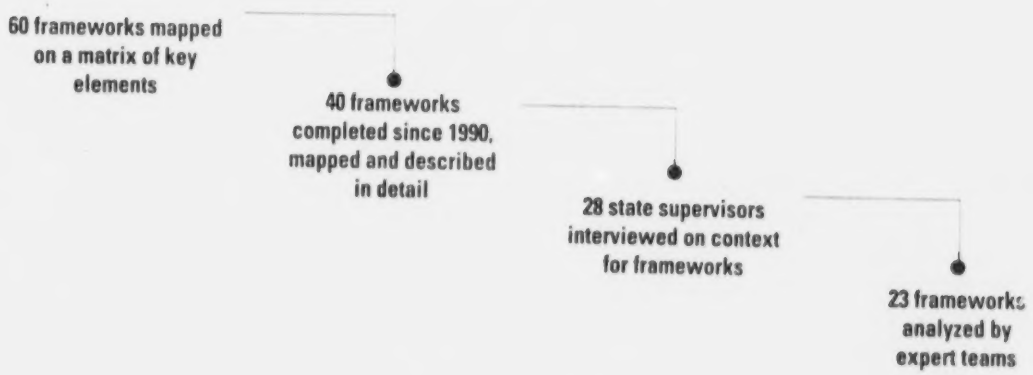
Given the policy and evaluation interest in analyzing the role of state frameworks in the 25 SSI states and the 16 Eisenhower framework grantee states, we selected frameworks from these states if they were completed or in review draft stage.

The whole group of review team members included 15 mathematics, science, and curriculum experts representing the mathematics and science professional communities and state departments of education (including seven members of the expert panel for the study design), plus education research staff. Staff of the NSF and the U.S. Department of Education also attended the review sessions. The review teams were asked to read the frameworks in advance of the team sessions. Each member received his or her assigned frameworks, as well as the results of the staff content analysis of the frameworks.

The first step in the team analysis was a written review for each framework, based on the analysis questions. The team reviews of each framework were read by staff and other panelists for consistency in

FIGURE 1

Study Design Summary


60 frameworks mapped on a matrix of key elements
40 frameworks completed since 1990, mapped and described in detail
28 state supervisors interviewed on context for frameworks
23 frameworks analyzed by expert teams

approach and completeness of questions, and revisions were made based on feedback. All the review teams met together to consider commonalities, differences, and examples of good practice among math frameworks and among science frameworks. The whole group identified patterns of practice across frameworks and developed consensus on major issues for improving and developing frameworks.

The scope of the study and the number of frameworks included in each step are summarized in Figure 1. This study is an initial review of the content of frameworks across many states. The "findings" and "issues" presented in the report are preliminary statements based on a set of hypotheses, content analysis across frameworks, and consensus among experts on the quality of specific aspects of recent frameworks. The findings and issues should be placed in the context of each state's purposes and functions for the framework.

Organization of the Report

The findings from the study are described in the next three chapters of the report. Chapter 2 provides our findings on the current status of frameworks and state context, including framework purposes, state mandates and funding, and steps in development. Chapter 3 explains the results of the CCSSO content analysis of key elements and qualitative analysis of issues for framework development. Chapter 4 presents findings on the relationship of state frameworks and mathematics and science reform, including linkages to policies and framework dissemination and implementation. Finally, we present a summary of the study and discuss tools for mathematics and science reform.

Chapter 2: Current Status and Development of Mathematics and Science Frameworks

Results from CCSSO's 1994 survey of all states show that states are very active in developing state curriculum frameworks. The total number of states with a content-related document in mathematics and science has increased, and the number of states with a mathematics or science document called state "framework," either in place or being developed, has also increased.

This chapter describes the current status of mathematics and science frameworks by state, and outlines the activities of states in developing new frameworks. We provide information on differences and similarities in the state context, purposes, uses and development process for state frameworks.

The current state information on curriculum frameworks follows earlier work by CCSSO on tracking state policies, including curriculum guides and frameworks (Blank and Espenshade, 1988; Blank and Dalkilic, 1992). The Council has developed a system of statistical indicators of the condition of science and mathematics education in elementary and secondary schools, with two biennial reports produced (Blank, 1991, 1993) and a third planned for 1995. The reports on states' policies and science and mathematics indicators have been supported by NSF.

Status of Frameworks in All States

All states reported to CCSSO in 1994 on curriculum frameworks and other content-related state documents in mathematics and science. The survey used a broad definition to identify current documents and current state activities in developing frameworks.

Table 1 gives a state-by-state summary of documents in place and being developed. The table shows: current titles of mathematics and science content documents (including "frameworks," "guides," "objectives," and "standards"),[1] the year the current document was published, the year a new framework is expected to be completed (if applicable), the number of pages of the current document, and whether the document was analyzed in the CCSSO study. States could choose to have their document listed but not be analyzed in the study (if, for example, the existing document is being revised or replaced). Figure 2, summarizing some of the information in Table 1, shows how many states have a framework or content-related document in place, and the number in the process of developing a framework in mathematics and science.

In mathematics, 42 states had a state framework or content-related document as of December 1994, with 32 documents covering mathematics only and 10 that combined mathematics and science or core academic subjects. In science, 42 states had a state document, with 32 covering science only and 10 had

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[1] The documents currently in place have three common criteria:

- All address content of mathematics or science education.
- All are published under the auspices of state boards of education, but are written by teams that include outside content experts, state agency personnel, and local educators.
- All indicate that the state framework or content-document is *not* a prescribed curriculum or a lesson plan for teaching mathematics or science.

TABLE 1

State Curriculum Frameworks and Content-Related Documents in Mathematics and Science

(December 1994)

State	Document	Year	Developing or Revising Date	No. of Pages	CCSSO Analysis
Alabama	*Alabama Course of Study Mathematics*	1989		199	✓
	Alabama Course of Study Science	1989	1995	244	✓
Alaska	(Developing Frameworks)		1995		
Arizona	*Arizona Essential Skills for Mathematics*	1992	1995		
	Arizona Science Essential Skills	1990	1995	49	✓
Arkansas	*Arkansas Mathematics Curriculum Framework, Draft*	1993		70	✓
	Arkansas Science Curriculum Framework, Draft		1995		
California	*Mathematics Framework for California Public Schools, K-12*	1992		220	✓
	Science Framework for California Public Schools, K-12	1990		200	✓
Colorado	*Model Content Standards for Mathematics, Science (+ 4 subjects), Draft*	1994	1995	140	✓
Connecticut	*A Guide to Curriculum Development in Mathematics*	1981	1995		
	A Guide to Curriculum Development: Science	1991	1995	126	✓
Delaware	*New Directions for Education in Delaware: Mathematics Content Standards, Draft*	1994	1995	32	
	New Directions for Education in Delaware: Science Content Standards, Draft	1994	1995	40	
District of Columbia	*Mathematics, Science, & Technology Framework, K-12, Draft*	1993	1995	100	✓
Florida	*Mathematics Curriculum Framework, Draft*		1995		
	Science for All Students: The Florida PreK-12 Science Curriculum Framework	1994		71	✓
Georgia	*Quality Core Curriculum Mathematics K-12*	1988	1995	101	✓
	Quality Core Curriculum Science K-8/Secondary Science Curriculum in Georgia	1988	1995	49	✓
Hawaii	(Developing Frameworks)		1996		
Idaho	*Idaho K-12 Mathematics Content Guide and Framework, Draft*	1994		120	✓
	Elementary Science Course of Study and Curriculum Guide	1989	1995	76	✓
Illinois	(Developing Mathematics and Science Frameworks)		1995		
	State Goals for Learning and Sample Learning Objectives, Biological and Physical Sciences	1986			
Indiana	*Mathematics Proficiency Guide*	1991		248	✓
	Key Elements of the Science Proficiency Guide	1993		55	✓
Iowa	*A Guide to Curriculum Development in Mathematics*	1987	1995		
	A Guide to Curriculum Development in Science	1991	1995	78	✓
Kansas	*Kansas Mathematics Curriculum Standards*	1993		97	✓
	Curricular Standards for Science	1993		34	✓

State Curriculum Frameworks and Content-Related Documents in Mathematics and Science (cont.)

State	Document	Year	Developing or Revising Date	No. of Pages	CCSSO Analysis
Kentucky	*Transformations: Kentucky's Curriculum Framework (Core Subjects, Two Volumes)*	1993	1995	504	✓
Louisiana	*Louisiana Mathematics Framework, Draft Content Section*	1994	1995	57	✓
	Earth Science, Grade 8 (Developing Science Framework)	1991	1996	37	✓
Maine	(Developing Frameworks)		1995		
Maryland	*Mathematics, Maryland Curricular Framework*	1985		42	✓
	Science: A Maryland Curricular Framework	1985		38	✓
Massachusetts	*Massachusetts Curriculum Framework for Mathematics, Draft*	1994		165	✓
	Massachusetts Curriculum Framework for Science and Technology, Draft	1994		142	✓
Michigan	*Michigan Essential Goals and Objectives for Mathematics Education*	1990		40	✓
	Michigan Essential Goals and Objectives for Science Education	1991		160	✓
	Core Curriculum Content Standards, Draft	1994		126	
Minnesota	*Model Learner Outcomes for Mathematics Education*	1991	1995	153	✓
	Model Learner Outcomes for Science Education	1991	1995	123	✓
Mississippi	*Mississippi Curriculum Structure: Mathematics*	1993	1995	59	✓
	Mississippi Curriculum Structure: Science	1991	1995	30	✓
Missouri	*Core Competencies and Key Skills for Missouri Schools, 2-6, 7-10*	1990	1995	103	✓
Montana	(Developing Mathematics Framework)		1995		
	Science Can Make a World of Difference, Tool Kit for Science Curriculum Development	1991		66	✓
Nebraska	*Mathematics & Science Frameworks for Nebraska Schools*	1994		117	✓
Nevada	*Nevada Course of Study—Mathematics*	1994		13	✓
	Nevada Course of Study—Science	1994		18	✓
New Hampshire	*K-12 Mathematics Curriculum Framework, Draft*	1994		35	
	K-12 Science Curriculum Framework, Draft	1994		31	
New Jersey	*New Jersey Mathematics Standards, Draft*	1993	1995	63	✓
	Core Course Proficiencies: Science	1990		56	✓
New Mexico	*New Mexico Competency Frameworks (11 subjects)*	1992		22	✓*
New York	*Curriculum, Instruction, and Assessment Framework for Mathematics, Science, and Technology, Draft*	1994		100	✓
North Carolina	*Mathematics, K-8, Standard Course of Study*	1989		33	✓
	Mathematics, Grades 9-12, Standard Course of Study	1992		33	✓
	Teacher Handbook, Science K-12	1994		194	✓
North Dakota	*North Dakota Curriculum Frameworks (Math, Science, 3 subjects)*	1993		89	✓
Ohio	*Model Competency-Based Mathematics Program*	1990		213	✓
	Science: Ohio's Model Competency-Based Program, Draft	1994	1995	174	✓
Oklahoma	*Priority Academic Student Skills (10 subjects)*	1993		173	✓

State	Document	Year	Developing or Revising Date	No. of Pages	CCSSO Analysis
Oregon	(Developing Mathematics Framework)		1995		
	Science: Comprehensive Curriculum Goals, A Model for Local Curriculum Development	1989	1995		
Pennsylvania	*Mathematics Curriculum Framework*	1994		50	
	A Recommended Science Competency Continuum for Grades K-6 for Pennsylvania Schools	1990		61	✓
	Science and Technology Framework	1995		132	
Puerto Rico	(Developing Science Framework)		1995		
Rhode Island	(Developing Draft Frameworks)		1995		
South Carolina	*Mathematics Curriculum Framework*	1993		157	✓
	Science Framework, Draft		1995		
South Dakota	*South Dakota Mathematics and Science Benchmarks, Draft*		1995		
Tennessee	*Mathematics Curriculum Framework, Grades 9-12*	1991		39	✓
	Science Framework, K-8; Secondary Science Curriculum Framework	1990		39	✓
Texas	*Revised Essential Elements: Fundamentals of Math, Consumer Math, Algebra I, Algebra II, Geometry, Trigonometry, Calculus*	1991	1995	17	✓
	Science Framework K-12		1996		
Utah	*Mathematics Core Curriculum, Grades K-4, Grades 5-7*	1993		70, 53	✓
	Mathematics Core Curriculum, Grades 9-12	1993		79	✓
	Science Core Curriculum, K-6, Draft	1994	1995	34	✓
	Science Core Curriculum, 7-12	1992	1995	74	✓
Vermont	*First Draft Content Standards: A First Step Toward Vermont's Common Core Framework for Curriculum and Assessment*	1994		40	
Virginia	*Standards of Learning Objectives for Virginia Public Schools: Mathematics*	1988	1995	35	✓
	Standards of Learning Objectives for Virginia Public Schools: Science	1988		45	✓
Washington	*Guidelines for K-8 Mathematics Curriculum*	1985	1995	56	
	Guidelines for Grades 9-12 Mathematics Curriculum	1985		66	
	Guidelines for Science Curriculum in Washington Schools	1985	1995	88	✓
West Virginia	*Mathematics Program of Studies: Instructional Goals and Objectives*	1991		109	✓
	Educational Program Definition (Science)	1986		18	✓
	Science Curriculum Framework	1992			
Wisconsin	*A Guide to Curriculum Planning in Mathematics*	1986	1995	339	✓
	A Guide to Curriculum Planning in Science	1986	1995	183	✓
Wyoming	*Standards of Excellence for Mathematics Education*	1990		13	✓
	Standards of Excellence for Science Education	1990		19	✓

Source: Council of Chief State School Officers, Study of State Curriculum Frameworks in Mathematics and Science, 1995.

combined frameworks. A current document with "Draft" in the title generally means it is being reviewed before final approval by the state. The draft editions of frameworks were in varying stages of completion. Some drafts were rough, and state staff expected they would change substantially; others were almost final and were expected to change minimally as a result of the statewide review.

State science and mathematics supervisors also reported on current state efforts to develop a new framework. Summarizing the column showing the year new frameworks are expected to be completed: 21 states are developing a mathematics framework, 25 states are developing a science framework, and four are developing a combined framework (see Figure 2). In some cases, a state is developing a new "framework" and currently has a document called curriculum "objectives" (e.g., Illinois, Louisiana) or "standards" (e.g., New Jersey). In states such as Alaska, Hawaii, and Maine, the new framework will be the first state content-related document for mathematics or science.

FIGURE 2

Status of State Curriculum Frameworks

(as of December 1994)

	Mathematics	Science	Combined Mathematics and Science
States with a framework or curriculum-related document	32	32	10
States developing a framework	21	25	4

(N = 52: 50 states plus Washington, DC and Puerto Rico)

Of the 10 combined mathematics-science frameworks, three frameworks include mathematics and science (District of Columbia, Nebraska, and New York) and seven states combine three or more core subjects in the same document (Colorado, Kentucky, Missouri, North Dakota, New Mexico, Oklahoma, and Vermont).

The current state documents vary in length from less than 20 pages to over 500 pages, reflecting states' varied approaches and purposes. We record the number of pages in each document as a point of reference, not as a consideration of quality. Moreover, we reviewed what the state supervisor indicated to us was the core curriculum document for each state. In some cases, however, the document analyzed was only one of several related resources that, together, comprise its curriculum guidelines. Other supportive documents include broad state education goals, state assessment plans, teaching or implementation guides, professional development materials, and lists of teaching resources. (We itemize the related documents in Appendix E).

The last column in Table 1 indicates which state frameworks and content documents were analyzed by CCSSO in the study (beyond this initial listing). Documents submitted after August 1994 were not analyzed by CCSSO for this report. Of the 60 frameworks[2] analyzed, 40 were completed since 1990.

[2] Here and in the succeeding sections of the report, the term "framework" is used to refer to state frameworks or content-related documents.

State Context for Framework Development

Each state framework is developed within a specific state context, defined by a variety of factors, including state laws and policies, structure of the educational system, particular needs for curriculum leadership, and relationships between state-level and local educators. The fact of a different context for each state curriculum framework means that the purposes, organization, and elements included in the framework differ for each state. To better understand and analyze a particular state's curriculum framework, we considered the context of the document. Although we would prefer to have more detailed background information that might be collected through site visits, interviews, and analysis of other documents, the time and funding did not permit this level of analysis.

In Table 2, we report state context information obtained through the framework mapping process and interviews with curriculum supervisors in selected states. State context information in this report includes:

- Intent or purposes of the framework
- State mandates for framework development
- Funding sources
- Intended audiences or users for the framework
- Dissemination and staff development activities

Purposes of Frameworks in States. The conceptual-mapping results showed that three typical purposes or functions defined in frameworks are (1) developing student knowledge and skills in mathematics or science, (2) assisting local educators in designing curriculum and selecting materials, and (3) advancing and modernizing instruction and classroom practices. Other functions described in some frameworks are improving access and opportunity in mathematics or science and developing new approaches to student assessment.

The main purposes of frameworks defined by mathematics and science supervisors in 28 states, shown by Table 2, are as follows (more than one purpose is possible):

15 Present higher standards or assist local districts and schools to meet national standards.

12 Guide local reform of mathematics or science education.

10 Assist with developing local curriculum.

7 Provide basis for improving statewide assessment.

The results show that over half of the state frameworks have a major purpose related to standards for mathematics or science—either setting state standards or defining national standards.

Although setting standards—a policy goal—is a main theme for frameworks, 12 state supervisors also described a broader purpose of guiding local reform. States such as Colorado and North Dakota view

TABLE 2

Context for Development of Selected State Curriculum Frameworks

(N = 28 Selected Recent Frameworks)

State Framework	Major Purposes for the Framework (according to state supervisors*)	Sources of Funding	State Mandate
Mathematics			
Arkansas (1993)	Guide to develop curriculum at local and district levels. Serve as a resource and guide for statewide assessment.	State funds, IKE Frameworks grant, and IKE state funds.	Yes, Act 236.
California (1992)	Provide a vision for mathematics educators. Provide criteria for instructional material.	$30,000 annual State budget.	Yes.
Idaho (1994)	Help move toward a more performance-based education system. Act as a quality model for local school systems and aid in improving the curriculum.	IKE state funds.	No, initiated by the Idaho Dept.
Indiana (1991)	Offer guidance to local level for the implementation of a statewide curriculum. Include guidelines for textbook assessment.	State funds.	No.
Kansas (1993)	Provide schools with benchmarks and standards to help guide their curricula.	State funds and IKE state funds.	Yes, 1992 state mandate.
Massachusetts (1994)	Raise education standards and promise of quality and equity for all. Provide more hands-on, inquiry-based education. Goals for education in coordination with Goals 2000.	SSI grant, IKE Frameworks grant, IKE state funds, and state funds.	Yes, June 1993 Reform Act.
New Jersey (1993)	Provide higher-level content standards with the framework to support them. Develop process for the education community and beyond to work together. Establish process for constant evaluation.	IKE Frameworks grant, New Jersey Mathematics Coalition funds, and IKE state funds.	Yes, mandate regarding content standards.
Ohio (1990)	Bring the state's local curriculum in line with NCTM standards. Aid development of district curricula.	State funds.	Yes, Senate Bill 140.
South Carolina (1993)	Desired a framework that was visionary yet usable right away; a framework that addressed change and allowed room for subsequent legislation.	State funds.	Yes, Act 135.
Texas (1991)	Intended to provide upgraded standards to help align with national standards; state testing based on the framework.	State funds.	Yes, mandate for core curriculum.
Utah (1993)	Intended to identify a new curriculum that goes beyond basic facts and intended to widen math curriculum to meet NCTM standards.	State funds and IKE state funds.	No.
Science			
California (1990)	Give direction to science reform.	State funds.	Yes, every 7 yrs.
Connecticut (1991)	Guide systemic reform on the local level.	State funds.	No.
Florida (1993)	Ensure that the local curriculum stands up to national standards and benchmarks.	IKE Frameworks grant and IKE state funds.	Yes, Blueprint 2000
Georgia (1988)	Conduct individual school evaluations and implement a solid curriculum by helping to show teachers what they are expected to teach.	State funds.	Yes, Quality Basic Education Act
Kansas (1993)	Focus curriculum development more on process and outcomes by helping teachers develop a process-oriented curriculum.	State funds.	Yes, Quality Performance Accreditation.

Context for Development of Selected State Curriculum Frameworks (cont.)

State Framework	Major Purposes for the Framework (according to state supervisors*)	Sources of Funding	State Mandate
Science, continued			
Michigan (1991)	Provide guidelines and benchmarks for proficiency in local curriculums. Intended to provide greater opportunity to learn and guidance in statewide assessment.	State funds and IKE state funds.	Yes, Michigan Public Act 1989-90.
Minnesota (1991)	Provide assistance to school districts developing K-12 curriculums. Help educators take a global view in building a curriculum and show how to teach to the national standards.	State funds and Northern States Power grant.	Yes.
North Carolina (1994)	Change the way science is viewed and how it is taught.	State funds and IKE state funds.	Yes.
Ohio (1994)	Provide guidance in producing local curriculums.	State funds.	Yes, House Bill 270.
Utah (1993)	Instrument in unifying and aligning instruction to primary goal "students will value and use science as a process of obtaining knowledge based upon observable evidence."	State funds and West Lab grant.	Yes.
Combined Math & Science			
Colorado (1994)	Establish higher standards for Colorado math to encourage higher achievement. Promote the theme that all students can learn. Act as a vanguard for education reform. Express what educators feel students should know in science.	State funds $150,000 for six frameworks.	Yes, Colorado House bill HB93-1313.
District of Columbia (1993)	Encourage the integration of math and science with other curricula. Develop the curriculum in specific math and science courses.	District funds, IKE Frameworks grant, and IKE state funds.	No.
Kentucky (1993)	Produce user-friendly document for curriculum writers and developers.	State Department of Education core funds.	Yes, KRS 158.6451.
Nebraska (1994)	Offer guidance to school districts by helping to improve concepts and skill objectives within the curriculum and aiding teachers in how to effectively teach the curriculum.	IKE Frameworks grant and IKE state funds.	No.
New Mexico (1992)	Help shift mathematics curriculum from teaching to a checklist to teaching to students' needs, and less prescriptive group of curriculum objectives.	State funds.	Yes.
North Dakota (1993)	Define what students should know and what they should be able to do in terms of math curriculum. Develop and define state assessment.	Chapter 2 (federal) funds.	Yes.
New York (1994)	Guide schools in developing curricula and curriculum assessment programs. The framework aims to raise New York to a higher level of standards.	IKE Frameworks grant and IKE state funds.	Yes, State syllabus report.

Note:

IKE state funds = U.S. Department of Education Eisenhower Mathematics and Science Education State Program (all states).
IKE Frameworks grant = U.S. Department of Education Eisenhower State Mathematics and Science Curriculum Frameworks Development Projects (16 grants to states in 1992, 1993). **NCTM** = National Council of Teachers of Mathematics.

* *Information from interviews with state science and mathematics supervisors for 28 selected frameworks, including Statewide Systemic Initiative (SSI) and Eisenhower Frameworks Projects states, July 1994."Frameworks Projects (16 grants to states in 1992, 1993).*

Source: Council of Chief State School Officers, Study of State Curriculum Frameworks in Mathematics and Science, 1995.

the main framework purpose as defining standards for local educators. Other states, such as Idaho, Kansas, South Carolina, and Kentucky, see the framework purpose as producing a document that is user friendly and that could be applied directly by local educators in modeling good practice and writing a curriculum. Another group of states (10) did not respond about standards or reform, but expressed the basic purpose of guiding local curriculum development. One-fourth of supervisors (7) saw a major purpose of their framework as improving their state student assessment program in mathematics or science.

State mandates. State mandates for framework development were reported by supervisors for 20 of the 28 frameworks. In seven states (Arkansas, South Carolina, Colorado, Michigan, Ohio, Kentucky, and Massachusetts), the mandate is from a state law, whereas in 13 states the mandate is the result of state board policy. The remaining eight state frameworks were developed through an initiative of the state department of education. The conceptual-mapping process, which covered 60 frameworks, confirmed that about two-thirds of frameworks were developed as a result of a state mandate.

Funding for development. Sources of funding for developing state frameworks include state funds, competitive grants to states from the U.S. Department of Education (Eisenhower Mathematics and Science Program), state funds under the Eisenhower Mathematics and Science program, and other sources.

The funding of 28 recent frameworks can be summarized as follows:

13 State funds were the only funding source.

13 State *and* federal funds supported framework development.

2 State funds and private sources supported the framework.

No clear pattern emerged when comparing funding sources with purposes, although the frameworks funded by Eisenhower Curriculum grants were all reported to have the purpose of providing or assisting with standards, as well as guiding local curriculum. This study did not follow the effects of different levels of funding in framework development. We would expect that the process of development would differ markedly according to the extent of available support.

Intended Audiences and Users. The conceptual mapping of 40 state framework documents completed since 1990 showed that all frameworks described an intended audience or user group for the framework. Table 3 shows that 32 of 40 frameworks cited the primary intended users as teachers, and 30 of 40 listed curriculum developers or planners as the intended users. Local decision makers were frequently cited, with almost one-half of frameworks giving administrators as a primary intended user (18 of 40), and board members were cited as main users in two frameworks. Developers of student assessments were identified as primary users in three frameworks, and community constituents were primary users in two frameworks. In addition, assessment developers were described as secondary users of frameworks in 10 states, and community members in six states.

Steps in Framework Development. Table 4 shows that recent frameworks have been developed with a number of common steps or activities. Of the 40 frameworks developed since 1990, 33 had an ex-

TABLE 3

Primary Intended Users Defined in State Frameworks

(N = 40 frameworks completed since 1990)

Intended Users	Math (N = 16)	Science (N = 16)	Combined (N = 8)	Total (N = 40)
Teachers	11	14	7	32
Curriculum developers/planners	10	13	7	30
Administrators	6	9	3	18
Assessment developers	1	2	0	3
Board members	1	0	1	2
Parents	0	0	0	0
Business partners	0	0	0	0
Other community constituents	1	0	1	2

Note: More than one primary user could be indicated.

Source: Council of Chief State School Officers, Study of State Curriculum Frameworks in Mathematics and Science, 1995.

pert panel that typically included scientists or mathematicians, science or mathematics educators, and others in defining, outlining, reviewing, and assisting with the framework development. The majority of states (29 of 40) had teachers involved in some phase of writing, either drafting, editing, or providing text from examples or experience. A majority of recent frameworks (25 of 40) used "model documents," such as the NCTM Standards, AAAS Benchmarks, or other state frameworks, as a key source of information in development. Successive drafts and review were a step reported in 21 frameworks, though only three frameworks described the use of a pilot study (such as trying it out in developing local curriculum). Fourteen frameworks provided for wide dissemination for comments and review.

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TABLE 4

Framework Development Activities Described in State Frameworks

(N = 40 frameworks completed since 1990[1])

Mathematics

DEVELOPMENT ACTIVITIES	STATES																TOTAL
	AR	CA	ID	IN	KS	MA	MN	MS	NJ	NV	NC	SC	TN	TX	UT	WV	16
Expert panel		◆	◆	◆	◆	◆	◆		◆		◆	◆	◆			◆	
Model documents	◆	◆	◆	◆	◆	◆	◆		◆		◆	◆	◆				
Teachers involved in writing	◆	◆	◆	◆	◆	◆			◆		◆	◆	◆			◆	
Successive drafts reviewed	◆	◆	◆	◆	◆	◆			◆		◆	◆				◆	
Pilot study		◆		◆													
Wide dissemination		◆	◆	◆					◆		◆	◆	◆			◆	

Science

DEVELOPMENT ACTIVITIES	STATES																TOTAL
	CA	CT	FL	IA	IN	KS	LA	MA	MI	MN	MS	MT	NC	NV	OH	UT	16
Expert panel	◆	◆	◆	◆	◆		◆	◆	◆	◆	◆	◆	◆		◆	◆	
Model documents	◆	◆	◆		◆	◆		◆	◆	◆			◆		◆		
Teachers involved in writing	◆	◆	◆			◆	◆	◆	◆	◆			◆			◆	
Successive drafts reviewed	◆	◆	◆				◆	◆	◆				◆			◆	
Pilot study															◆		
Wide dissemination	◆						◆						◆				

Combined Mathematics & Science

DEVELOPMENT ACTIVITIES	STATES								TOTAL
	CO	DC	KY	ND	NE	NM	NY	OK	8
Expert panel	◆	◆	◆	◆	◆	◆	◆	◆	
Model documents	◆	◆	◆	◆			◆		
Teachers involved in writing	◆	◆	◆	◆	◆	◆	◆	◆	
Successive drafts reviewed		◆	◆				◆	◆	
Pilot study									
Wide dissemination	◆	◆	◆						
Other					◆				

Source: Council of Chief State School Officers, Study of State Curriculum Frameworks in Mathematics and Science, 1995.

Chapter 3: Results of Content Analysis and Qualitative Analysis of Frameworks

This chapter presents results of the content analysis of frameworks through the conceptual-mapping process, as well as results from the qualitative analysis by expert review teams. We have organized the analysis into four categories:

- *Vision for Mathematics/Science Education*: Statement of vision for state and rationale for framework, and the relationship of the vision to how content is organized and presented.
- *Content Organization and Standards*: Content organization and cross-cutting themes, terms used to express content statements or standards, and sample of a content statement.
- *Communication of Content and Pedagogy*: How the framework presents and communicates the desired mathematics or science content; the features or methods used to improve understanding and implementation of content; and instructional practices, activities, or examples that are suggested.
- *Equity in the Curriculum*: Vision for mathematics/science for all students; strategies or recommendations for organizing and delivering to all, regardless of race/ethnicity, gender, socioeconomic status, or disability.

The CCSSO conceptual-mapping process confirmed that in the 1990s states are taking new approaches to state curriculum frameworks in mathematics and science. For several aspects of the analysis, we present information on all 60 frameworks that were covered in the conceptual mapping. More detailed analyses and discussion are presented for 40 mathematics and science frameworks completed since 1990.

This chapter discusses issues for framework development, which were the results of the qualitative review and analysis of 23 recent frameworks by the expert review teams (see list in Appendix D). In this and the following chapters, we have highlighted the "issues" under each section. Following the discussion of content analysis and qualitative analysis, we have included examples of effective "practices" from state frameworks. The issues, and selection of examples, are based on the collective judgments of the expert review teams. They do not reflect a theory or view of "one best way" to organize and write frameworks. The issues and examples will not apply to all states, since frameworks differ in purpose and function by state.

Vision for Mathematics/Science Education

The NCTM *Standards* (1989) made a strong statement on the need for mathematics educators, the public, and the nation to establish a new vision for mathematics in the schools. An important thrust of the release and dissemination of the *Standards* has been to build a new vision for the overall K-12 mathematics curriculum, the need for mathematics in the lives and careers of all students, and a logic for reform of mathematics in the schools. The concept of vision and rationale was adopted by CCSSO as a key element for analyzing the content of all mathematics and science framework documents.

A vision statement sets the rationale for a state framework in relation to state needs.

Many framework documents have an introductory section that includes a statement of vision or goals for mathematics/science education in the state's schools. The conceptual mapping of 60 framework documents showed that states have adopted the idea of providing a broad vision or rationale for the need for mathematics or science education reform. All 60 state frameworks included some statement of vision or rationale. Recent frameworks typically quote or cite national standards and reports recommending mathematics and science reform. State framework writers use the introductory statement to relate broad ideas and goals for mathematics and science education to the specific purposes and structure of the framework.

The expert review teams found that the vision statements in recent frameworks are generally consistent with the ideas and approach to mathematics and science education found in emerging national standards documents. A well-stated vision is critical in giving state educators and the public a strong underlying rationale for the approach to mathematics or science reform and the role of the state framework. The vision statements differ in their effectiveness in relating broad general goals for reform of mathematics or science education to specific concerns, needs, and interests of the state. The following are examples of frameworks that provide vision statements that relate broad curriculum goals to state needs: Massachusetts mathematics and science, New Jersey mathematics standards, California math, South Carolina math, and Kentucky combined mathematics/science (see Exhibit 1).

Content Organization and Standards

Statements, recommendations, or suggestions about the breadth, scope, and emphases of the content of mathematics or science education are central to all of the frameworks that were reviewed. Frameworks vary in how content is organized and presented; how it is related to the state's vision for mathematics or science education; and the extent to which the framework relates the content recommendations to pedagogy and curriculum implementation, state policies, and conditions in schools. The analysis of the content sections of frameworks is presented in two ways: first, by examining how content statements, or "standards," are written or expressed in frameworks, and second, by considering how states organize science or mathematics content in the framework.

Currently, many states are developing or reviewing content standards for core subject areas. Table 5 provides a summary of what states currently have available in mathematics and science that might be considered as a "content standard." Because these frameworks predate the Goals 2000 legislation, they do not always refer to their content goals as "content standards." However, more recent frameworks' standards probably are more consistent with the new language and concepts outlined by the Goals 2000 legislation. The analysis is not intended to endorse or recommend one way that content standards should be written. CCSSO's review and analysis of state frameworks clearly shows that states have different goals and uses for frameworks, and the organization and presentation of content exhibit these differences.

This approach to analysis of mathematics and science content in frameworks provides direct examination of how content statements are expressed and organized. It does not rely on a respondent's views about the framework or a typology based on state intent or purpose.

New Jersey Mathematics Standards, (p. 5)

The kind of mathematics teaching described in the previous pages is already a reality in a small number of New Jersey classrooms. Its major characteristics are easy to identify and, taken together, they represent a vision for what all mathematics education in the state should be:

- the students are excited by and interested in their activities;
- they work together to find solutions for what they perceive to be real problems;
- technology and other tools are used as an integral part of the process;
- the learning is conceptually based, meaningful, and connected to both previous mathematics learning and the real world; ...

South Carolina, Mathematics Curriculum Framework, (p. 9)

Every student in South Carolina must learn the mathematics necessary to experience a successful life. South Carolina schools advocate mathematical literacy as a lifelong necessity for an informed citizenry. Mathematical literacy enables an individual to use exploration, conjecture, logical reasoning, and a variety of mathematical techniques to solve problems effectively. South Carolina students must also learn to value mathematics and become confident in their use of mathematics. The combination of all of these components define "mathematical power." ...

Mathematics equity for all students, regardless of their race, gender, ethnic background, or previous success in mathematics, requires excellence for all and high expectations for all. Accordingly, all students in South Carolina must experience a common core of relevant mathematics.

Exhibit 1, pg. 2 Examples of Vision/Rationale

Science Framework for California Public Schools, (p. vii)

"This *Science Framework* calls for a new dynamic in science learning. We want our students to be actively engaged in learning about the natural and technological world in which they live. ...The expectation that students be active learners is favored throughout the curriculum, but nowhere is it more demonstrable than in applying the five sense to the learning of science. ...

We need to move beyond the simplistic dichotomy that emphasizes just content or process. Instead, we need to merge the two in a way that students see the meaning and utility of the scientific issues and ideas.

Transformations: Kentucky's Curriculum Framework, (p. 81)

As mathematics becomes more than calculation, education in mathematics must become more than mastery of arithmetic. Geometry, measurement, chance and data analysis are as important as calculation in achieving mathematical power. To prepare students to use mathematics in the 21st century, today's curriculum must invoke the full spectrum of the mathematical sciences. The six KERA learning goals support these expectations for the mathematics curriculum. Mathematics spans all KERA learning goals.

Transformations: Kentucky's Curriculum Framework, (p. 49)

Science is a way of knowing. It is a way of solving problems. It is a way of organizing information, seeing relationships, understanding how things work, keeping a proper perspective, recognizing the consistency of the universe, and observing change. ...

In the past, emphasis has been on the 'What' rather than the 'How' content rather than process. Teaching the 'What' of science is important, but students need to use the 'How' as well. There must be an integration of the two, along with the development of a positive attitude toward science, in order to keep the balance.

Standards set expectations for students.

The NCTM *Curriculum Standards*, AAAS *Benchmarks*, and NRC *Science Education Standards* all use statements about standards that specify content areas to be taught, and they establish expectations of what a student should know and can do with the content. State frameworks include content "standards" or standards-like statements that the state expects students to meet.

The review teams found that frameworks differ in the degree to which standards statements and language are consistent with the expectations that national standards are establishing for students. Some frameworks include standards statements that ask for only a low level of cognition, such as "know types of fossils," as opposed to a statement such as "conduct investigation to identify and explain differences in fossils." The review teams took the position that content standards are less useful when written as a checklist of content topics to be covered or presented to students. The national standards are written as longer statements with several paragraphs explaining what is expected of students. The following are examples of frameworks with state standards that used language that was consistent in setting appropriate expectations for students: New Jersey mathematics standards, Ohio science, Kentucky integrated, Arkansas math (see Exhibit 2 for examples).

Table 5 shows examples of a content statement, or standard, for each framework in the study. **Content statements in frameworks vary from broad goals for mathematics or science content to specific topic and skill objectives for each K-12 grade.** Three kinds of information are reported in each state box in Table 5: (1) the main term states use to organize and recommend subject content, such as "standard," "objective," or "skills"; (2) the number of such statements in the framework; and (3) an example from the state framework. The example of a content standard or statement is intended to show how each state has approached the writing and organization of content statements. For mathematics, we chose a statement at the middle-grades level (grades 6-8) that addressed algebra content. For science, we chose a statement for middle grades that addressed life science.

An example of different state approaches to "content statements" is illustrated by the first two states, listed alphabetically under mathematics frameworks in Table 5. Arkansas's framework (1993) defines 13 content standards that are linked across all K-12 grades. The framework describes how a standard would apply to curriculum and instruction for main grade blocks. For example, the "content standard" for algebra and functions at the middle-grades level reads "student will use the language of algebra as a representational tool." Alabama's document (1989) calls their statements "student outcomes," which are written by grade (K-8) and course (9-12), with from 60 to 70 outcomes per grade. An "outcome" (for Alabama) defines a specific student skill; for example, at grade 8, an outcome is "factor a common monomial from an algebraic expression." The content section of the document is largely composed of lists of outcome statements by grade.

Based on the conceptual mapping, the structure or scope of content statements, or "standards," can be summarized as follows:

Mathematics Frameworks: (n = 24)

- Content statements cutting across K-12 grades (5 to 15 statements): California, Arkansas, Louisiana, Maryland, Minnesota, New Jersey, Wyoming.

New Jersey Mathematics Standards, (p. 33)

Standard 16: All students will develop their understanding of algebraic concepts and processes through experiences which enable them to describe, represent, and analyze relationships among variable quantities and to apply algebraic methods to solve meaningful problems.

Experiences will be such that all students building upon the K-4 expectations in grades 5-8 will:

E. understand and use literal variables, expressions, equations, and inequalities;

F. represent situations and number patterns with concrete materials, tables, graphs, verbal rules, and standard algebraic notation;

G. use graphing techniques to show the relationship between distance on a number line and arithmetic operations and absolute value for rational numbers;

H. analyze tables and graphs to identify properties and relationships;

I. understand and use the rectangular coordinate system…

Arkansas Mathematics Curriculum Framework, (p. 10)

STRAND 5: ALGEBRA AND FUNCTIONS

CONTENT STANDARD 1

The student will use the language of algebra as a representational tool.

STUDENT LEARNING EXPECTATIONS

GRADES 5-8

5.1.8 Visualize algebra as the bridge between arithmetic and higher level mathematics.

5.1.9 Use manipulatives and technology to develop the concepts of variables, expressions, and equations.

5.1.10 Represent, explore and analyze situations and number patterns with tables, graphs, and equations.

5.1.11 Summarize the algebraic relationships discovered through explorations.

CONTENT STANDARD 2

The student will use algebraic concepts to model, solve and test solutions to mathematical and real-world problems.

STUDENT LEARNING EXPECTATIONS

GRADES 5-8

5.2.4 Conduct informal investigations. …

Transformations: Kentucky's Curriculum Frameworks, (p. 88)

Example of an Algebra standard for middle grades:

Learner outcome 2.8: Students demonstrate understanding of concepts related to mathematical procedures.

- Solve equations with concrete, pictorial, and abstract methods.
- Translate from concrete, pictorial, and verbal expressions to mathematical expressions and vice versa.
- Use models and investigations to construct algorithms using rational numbers.

Transformations: Kentucky's Curriculum Frameworks, (p. 62)

Example of a life science standard for middle grades:

Learner Outcome 2.3: Students identify and describe systems, subsystems, and components and their interactions by completing tasks and/or creating products.

- Design a new system or modify an existing one. Analyze the effects and limitations.
- Evaluate the effects of subsystems and their components on a system.
- Investigate the role of energy flow in systems.
- Demonstrate how a single system can have multiple functions and applications.
- Investigate and illustrate a system; identify its components and interrelationships with other systems

TABLE 5A

Mathematics Content Statements in State Curriculum Frameworks

(N = 24 Mathematics Frameworks in CCSSO Study)

State	Content Statement
Alabama (1989)	Alabama defines ***student outcomes*** for each grade, organized in 7 content areas and 60–70 outcomes per grade. E.g., Area: Algebra: Develop an understanding of mathematical/algebraic expressions. Student outcome 50: Factor a common monomial from an algebraic expression.
Arkansas (1993)	Arkansas framework is based on 13 ***content standards*** applicable to all grades. E.g., content standard 1 (algebra and functions strand): Student will use the language of algebra as a representation tool.
California (1992)	California defines 13-14 ***content standards*** by grade block. E.g., Standard 9: Algebra: In grades five through eight, the mathematics curriculum should include explorations of algebraic concepts and processes so that students can: understand the concept of variable, expression, and equation, represent situations and number patterns with tables, graphs, verbal rules, and equations...
Idaho (1994)	Idaho defines ***standards*** and ***performance objectives*** by grade block. Standards: 13 for grades K-4 , 13 for 5-8, and 14 for 9-12. E.g., Standard IX: Algebra: All students will explore algebraic concepts and processes. Performance Objectives: All students will (1) understand the concepts of variable, expressions, and equation, (2) represent situations and number patterns with tables, graphs...
Indiana (1991)	Indiana defines ***proficiency statements***, with 14 statements for grades K-4, 15 for grades 5-8, and 13 for grades 9-12. E.g., Proficiency Statement 14: Develop Explorations of Algebraic Concepts and Processes. Proficiency Indicators: (a) understand the concept of a variable, (b) represent points on a line or in a plane using numbers,...
Kansas (1993)	Kansas defines ***curriculum outcomes*** with 15 outcomes for each of the 3 benchmark grade levels (4, 8, and 10). E.g., Focus Area: Patterns, Functions, mathematical/Algebraic Functions, Algebraic Concepts and Relationships; Outcome 6: recognizes and describes linear functions and uses appropriate graphing technology to graph and analyze linear functions.
Louisiana (1994)	Louisiana defines 5 interwoven themes that encompass the ***strands*** of mathematics. E.g., Algebra, Grades 5-8: In problem-solving investigations, use appropriate manipulatives, models, graphs, tables, and technology to develop the understanding of concepts and to explore the applications of algebra. Explore student- and teacher-generated methods for solving equations and inequalities.
Maryland (1985)	Maryland defines 6 ***goals*** with ***subgoals*** as a broad guideline for K-12 mathematics programs. E.g., Goal 2: To develop an understanding of the structure of mathematical systems. Subgoal 2.4: Understand concepts, properties, and processes of algebra. 2.4.4: The learner employs properties to solve equations and inequalities.
Massachusetts (1994)	Massachusetts defines ***content standards*** by grade block, with 9 standards for grades K-4, 9 for 5-8, 10 for 9-12, and 7 for Adult Basic Education. E.g., Grades 5-8, Standard 9: Algebra: In grades 5-8, the mathematics curriculum should include explorations of algebraic concepts of variable, expression, and equation...
Michigan (1990)	Michigan defines objectives under 8 ***content strands*** and 6 ***process strands***. The algebraic strand includes 55 objectives — 9 for grades K-3, 21 for grades 4-6, and 25 for grades 7-9. E.g., Algebra: To recognize and use the concept of variable in expressions. At this level, multiplication is denoted by juxtaposition of a number and a variable, or two or more variables.

State	Content Statement
Minnesota (1991)	Following broad state learner goals, Minnesota defines 10 ***model learner outcomes*** for grades K-12 with an outline of math content and skills under each outcome. E.g., Learner Outcome: The student will apply number relationships and functions. Students will demonstrate that they can evaluate a simple algebraic expression.
Mississippi (1993)	Mississippi defines ***skills*** for math education, with 20 to 30 skills per grade (K-8), and 20 to 50 skills per 9-12 course. E.g., Grade 7: Solve word problems involving time using any one of the four operations. Note: Algebra content is not recommended at middle grade levels.
New Hampshire (1994)	New Hampshire defines 5 primary ***goals*** for grades K-12 with curriculum standards and proficiency standards given by grade level under each goal. E.g., Functions, Relations, and Algebra: Grades 7-12: Building upon the K-6 experiences, analyze functions and relations to describe how a change in one quantity results in a change in another.
New Jersey (1993)	New Jersey defines 18 ***standards***, including content, process and learning environment standards for K-12. E.g., Standard 16: All students will develop their understanding of algebraic concepts and processes through experiences which enable them to describe, represent, and analyze relationships among variable quantities and to apply algebraic methods to solve meaningful problems.
North Carolina (1989)	North Carolina's Standard Course of Study sets specific ***competency goals*** and ***objectives*** for each grade (K-8) within 7 common strands, and competency goals and objectives for each mathematics curriculum. E.g., Mathematics Grade 8: *3.* Pre-Algebra *d.* Investigate non-linear equations and inequalities informally.

State	Content Statement
Ohio (1990)	Ohio defines ***content dimensions*** and ***objectives*** under 8 mathematics strands, with 29 to 62 objectives listed per grade (K-8), and 14 to 34 per grade (9-12). E.g., Strand 5: Algebra, Grade 8: The student will be able to (1) use and relate tables, graphs, and equations to solve problem situations involving exponential growth and decay, simple interest, and compound interest...
South Carolina (1993)	South Carolina defines ***content standards*** by grade block for each of the 6 core strands. Strands include 30 for grades K-3, 44 for grades 3-6, 50 for grades 6-9, and 65 for 9-12 including 23 for advanced mathematics. E.g., Strand: Numerical and Algebraic Concepts and Operations (grades 6-9): Students will participate in problem-solving activities through group and individual investigations so that they can: Understand the concepts of variables, expressions, equations, and inequalities and gain confidence in thinking and communicating algebraically,...
Tennessee (1991)	Tennessee's framework for grades 9-12 defines ***content outlines*** for each course to be used in writing local curriculum. E.g., Algebra I, II. To Understand Linear Functions. *A.* Understand the concept of functions. *1.* Define a relation, domain of a relation, range of a relation and a function.
Texas (1991)	Texas defines ***essential elements*** as components of curriculum content that chapter 75 (a state law) requires school districts to teach in every subject of the state curriculum, and 45 to 55 essential elements are listed per grade (1-8). E.g., 8th Grade: Patterns, Relations and Functions: use of models and patterns to develop the algebraic concepts of relations and functions.

Mathematics Content Statements in State Curriculum Frameworks (cont.)

State	Content Statement
Utah (1993)	Utah defines ***content standards*** for each grade and course with an average of 13 standards in grades 1-7, and 7 to 16 standards for grades 8-12. E.g., Level 7, Standard 5070-09: The students will explore algebra concepts in an informal way to build a foundation for the subsequent formal study of algebra. 5070-0902: Analyze tables and graphs to identify properties and relationships...
Virginia (1988)	Virginia defines ***Standards of Learning Objectives*** by grade and course. E.g., the eighth grade course is designed to prepare students for an Algebra I course. *8.07* The student will solve simple linear equations in one variable.
West Virginia (1991)	West Virginia provides ***instructional goals*** for 3 grade blocks. Instructional objectives define the knowledge, skills, attitudes, and behaviors needed by students in developing mathematical competencies. E.g., Instructional Objectives, Level 8: Algebra: 51. Apply algebraic concepts using physical models, data, and graphs.
Wisconsin (1986)	Wisconsin defines ***objectives*** of an exemplary mathematics program organized into 7 strands. Objectives in each strand have been identified for groupings of grade levels: K-3, 4-6, 7-8, and 9-12. E.g., Grades 7-8: A6. Represent problem situations by using expressions involving variables.
Wyoming (1990)	Wyoming defines 8 broad ***goals*** for mathematics. E.g., recommendations for grades 5-8: (11) exploration of basic algebraic concepts and operations.

Source: Council of Chief State School Officers, Study of State Curriculum Frameworks in Mathematics and Science, 1995.

TABLE 5B

Science Content Statements in State Curriculum Frameworks

(N = 28 Science Frameworks in CCSSO Study)

State	Content Statement
Alabama (1989)	Alabama outlines concepts and ***instructional objectives*** for each elementary grade and secondary course in science, with about 50 objectives for grades K-8. E.g., Grade 7 Life Science: Instructional Objectives: The Cell Structure: Observe and identify plant and animal cell structures.
Arizona (1990)	Arizona defines 8 ***goals*** (K-12) that call for teaching higher-order thinking skills and use of conceptual themes. The goals are presented in about 40 Student Outcomes and Examples of Indicators for K-3, 4-8, and 9-12. E.g., Goal 3: Science Content: Structure and Function. Draw relationships between the characteristics of parts of organisms or components of systems and the actions they perform.
California (1990)	California presents 12-16 science ***content questions*** per life, physical, and earth sciences, and describes the underlying theories and knowledge about the questions appropriate to three grade blocks. E.g., Life Science, questions for Cells, Genetics, and Evolution: What are cells? What are their component structures and their functions?...
Connecticut (1991)	Connecticut defines ***objectives*** for students completing grades 3, 6, 8, and 12. In grade 8: 13 objectives for life science, 5 for physical science, and 4 for earth/space science. E.g., Life Science Objective: Living organisms carry on life functions. Illustrate that living organisms have life cycles, e.g., birth to death, seed to mature plant....
Florida (1994)	The Florida framework describes ***examples of concepts and activities*** by grade block within 8 broad knowledge strands of what students should be able to know and do. E.g., Strand 6: Processes of Life: (1) Design a model to demonstrate the correlation between healthful living and human body-system maintenance.
Georgia (1988)	Georgia defines ***objectives*** under 4 major science strands with 22 to 32 objectives per grade (K-8) and 26-44 objectives for 4 high school courses. E.g., Objectives, Life Science (7th grade): Recognizes characteristics of matter.
Idaho (1989)	Idaho defines four ***components*** of elementary science education. E.g., Science knowledge topics for grade 6 can be used as a framework for problem solving and concept development. Cells: Learn that all organisms are made of cells that can grow, develop, reproduce, use energy, and require food.
Indiana (1993)	Indiana defines 10 science ***proficiencies*** and 30 ***content themes*** (K-12). E.g., Theme H: Diversity of Life: students will understand and use the concept that living organisms, though they share many similarities, are richly diverse in structure and function.
Iowa (1991)	Iowa does not write content standards/statements. Under Life Science, suggestions are made for scope/sequence for 4 grade blocks. E.g., Grade 7-8 Human systems, ecology, microbes.
Kansas (1993)	Content is organized along 4 broad ***program outcomes***; each indicates 2 to 6 ***learner goals*** (K-12) and benchmarks for grades 2, 5, 8, and 11. E.g., Grade 8: Understands that forms and interactions of matter and energy determine the nature of the environment.
Louisiana (1991)	Separate curriculum guides were written for each curriculum. For example, Earth Science, Grade 8 guide has 5-10 performance objectives under each of eight concepts. E.g., Physical Geology: Differentiate the composition of layers of the earth.

Science Content Statements in State Curriculum Frameworks (cont.)

State	Content Statement
Massachusetts (1994)	Massachusetts defines ***fundamental understandings and skills*** under science content areas and domains with 60 skills defined for grades K-4, 84 for grades 5-8, and 103 for grades 9-12. E.g., Life Sciences: Diversity and Adaptation of Organism: short term changes in available food, moisture, or temperature of an ecosystem may result in a change in the number of organisms in a population.
Michigan (1991)	Michigan defines 70 ***objectives*** for elementary, middle, and high school levels. Every objective has an activity dimension (process) and a knowledge dimension (content). E.g., Strand: Understanding Cells: Middle school students should continue to develop their understanding of the first principle of cell theory,...Objective #2: Describe similarities/differences between single-celled and multicellular organisms.
Minnesota (1991)	Minnesota defines ***learner goals*** and 79 science ***essential learner outcomes*** for K-12. E.g., Life Science, Learner Goal:...each learner will accumulate and apply knowledge and develop the understanding to know the impact of natural phenomena on human life.
Montana (1991)	Montana defines ***learning objectives*** for grades K-6 and for each secondary course, as well as program goals and objectives by level. E.g., Life Science: The student will illustrate the flow of energy and matter among organisms in chains, webs, and pyramids.
Nevada (1994)	Nevada defines specific learning objectives (content and process) by grade 3, 6, and 8, and for categories of high school courses. E.g., By completion of grade 8 the student will: demonstrate understanding of these concepts and principles: *1.* Diversity: natural phenomena display a wide variety of similarities and differences.
New Hampshire (1994)	New Hampshire defines 6 curriculum strands with ***curriculum standards*** for grades K-12, and proficiency standards for grades 6 and 10. E.g., Curriculum Standard: Students will demonstrate an increasing ability to recognize patterns and products of evolution, including genetic variation, specialization, adaptation, and natural selection.
New Jersey (1990)	New Jersey defines ***core proficiencies*** for 6 science courses. For example, biology has proficiencies under 7 major biological topics. E.g., Ecology: Students will demonstrate the ability to: Describe the carbon and water cycles and explain their importance to all living things.
North Carolina (1994)	North Carolina defines ***competency goals and objectives*** by grade and course with a total of 65 for grades K-12. E.g., Grade 6, Competency Goal 6: The learner will construct an understanding of science concepts through patterns and cycles in the natural world. Objective 6.1: Investigate similarities and differences among monerans, protists, fungi, plants, and animals...
Ohio (1994)	Ohio provides sample ***"grade level (instructional) objectives"*** in 4 strands of scientific knowledge, with about 50 objectives per grade. E.g., Strand, Scientific knowledge: Objective, Grade 7: The learner will investigate the interdependence and similarities of organizations and their physical environments (e.g., mimicry, camouflage).
Pennsylvania (1995)	Science and technology are benchmarked in four levels with transitional standards to address eight general state learning outcomes. Content knowledge, process skills, and curriculum integration are developed within these contexts.

State	Content Statement
Tennessee (1990)	Tennessee lists science education ***skills*** by grade blocks, K-2, 3-4, 5-6, and 7-8 for each science area. E.g., Life Science: Grade 7: Developing an Understanding of the Growth and Development of Biological Life on Earth. Objectives 75211: To understand the basic structure and function of plant and animal cells.
Utah (1994)	Utah defines ***standards*** by science topic with 3 to 5 for each grade (K-6), and 10 to 15 per grades 7-12 courses. E.g., Life Science, Standard: The students will demonstrate an understanding of the characteristic processes of life. Objective (example): Describe the processes characteristic of all life: reproduction, movement, assimilation, growth, response, and energy transformation.
Virginia (1988)	Virginia outlines ***standards of learning objectives*** as well as ***descriptive statements*** that give an example of the objective: From 10 to 18 learning objectives per grade, K-12. E.g., Seventh Grade Life Science: Objective 7.7: The student will be able to construct and interpret cell models.
Washington (1985)	Washington defines 4 broad ***program goals*** for science education. Each grade block has 4 to 6 general objectives and learner outcomes to describe student learning. E.g., Grades 6-9: Goal #1: Develop and Apply Knowledge of Observational Facts, Concepts, Principles, and Processes of Science. Objective: C. To produce an understanding of basic generalizations, relationships, and principles applied in all sciences. Learner Outcome: *1.* Student will be able to a. use inferences to make generalizations. Instructional Implications: Physics: Show how atomic structure applies to all sciences. Life: photosynthesis as a chemical process.
West Virginia (1992)	West Virginia's science program of study outlines ***instructional objectives*** at each grade (K-8) and high school curriculum. E.g., Life Science Levels 7 or 8: Learning Outcomes (1.) Describe the cell theory; structure and function.
Wisconsin (1986)	Under 4 program components, ***objectives*** and activities are outlined for science in 4 grade blocks. E.g., Science Knowledge: Middle/Junior High School: *2.2* Objective: Change. The student shall understand that our environment is constantly undergoing change. *2.21* Living things have changed in form, appearance, and complexity over time. *2.211* Examine fossil records (photos or real fossils) and compare to present related species.
Wyoming (1990)	Wyoming defines broad ***goals*** for a science program. E.g., Components for Middle/Junior High Science: Exposing students to physical, earth and life science and relationships of these areas to their environment. Providing educational situations that incorporate laboratory, hands-on instruction, reading, discussion, research, and field experience.

Source: Council of Chief State School Officers, Study of State Curriculum Frameworks in Mathematics and Science, 1995.

TABLE 5C

Combined Mathematics and Science Content Statements in State Curriculum Frameworks

(N = 8 Combined Math/Science Frameworks in CCSSO Study)

State	Content Statement
Colorado (1994)	Colorado defines 17 ***content standards*** in math and science. E.g., *Science* standard 3.4: Students know that species evolve in response to changes in their environment. In grades 5-8, students extend their knowledge to include how to describe the role of chromosomes and genes in heredity;... *Math* Standard 2: Students use algebraic methods to explore, model, and describe patterns and functions. In grades 5-8 students extend their knowledge to analyze functional relationships to explain how a change in one quantity results in a change in another;...
District of Columbia (1993)	The District defines ***level outcomes*** for 7 math content strands and 3 science strands, with 30-35 outcomes, averaging 6-8 on each of 4 levels. E.g., *Mathematics:* Algebraic Concepts and Operations: Apply the concepts of variable, expression, and equation. Represent situations and number patterns with tables, graphs,... *Life Science:* Living Things: Investigate the cellular organization of living things in terms of structure and function.
Kentucky (1993)	Kentucky defines ***learner outcomes*** with 6 science and 12 math outcomes across the grade levels. E.g., Math: Learner Outcome 2.8: Students demonstrate understanding of concepts related to mathematical procedures. Solve equations with concrete, pictoral, and abstract methods. Science: Learner Outcome 2.3: Students identify and describe systems, subsystems, and components and their interactions by completing tasks and/or creating products. Design a new system or modify an existing one. Analyze the effects and limitations.
Nebraska (1994)	Nebraska defines ***measurable performances*** by strand, with 23-33 performances for each of 3 math levels, and 19-27 per 4 science levels. E.g., *Math* Strand: Develop appropriate mathematical models to represent actual situations. *Science* Strand: Cells and heredity: Design an investigation demonstrating how materials move in and out of cells.
New Mexico (1992)	New Mexico defines 5 *mathematics* student competencies to guide development and implementation of the K-12 program. E.g., Math: Become mathematics problem solvers. *Science education* competency is outlined by knowledge, skills, and citizenship. E.g., Science: Using topics from all science disciplines, students will demonstrate an understanding of balance and change through time in natural entities and systems.
New York (1994)	New York presents 9 ***content standards*** for math, science, and technology education, with each describing major areas of study, key competencies and concepts, and performance indicators. E.g., Middle Level, Standard 6: Mathematics, Students model the solution of simple equations, using concrete materials; graph linear relationships; develop procedures for computing with integers; use variables... Standard 4: Science, Living Environment: Describe the properties that distinguish living from nonliving things.
North Dakota (1993)	North Dakota defines ***content outcomes*** with 15 in mathematics and 6 in science. E.g., The student uses patterns, relationships, and algebraic concepts to solve problems. By the end of grade 8, students (a) develop and use tables, graphs, and rules to identify properties and relationships.
Oklahoma (1993)	Oklahoma defines 6 to 12 ***student skills*** for math and science by grade under process and content categories. E.g., Mathematics Grade 8: Content Skills: VIII. Algebraic Concepts The student will: A. Solve linear equations using concrete, informal and formal methods. Science Grade 8: *I.* Observing and Measuring: The student will: *A.* Identify similar or different characteristics in a given set of objects, organisms, or events.

Source: Council of Chief State School Officers, Study of State Curriculum Frameworks in Mathematics and Science, 1995.

- Content statements by grade cluster or block (10 to 25 per cluster): Idaho, Indiana, Massachusetts, Michigan, New Hampshire, South Carolina, West Virginia, Wisconsin.

- Content statements by grade (elementary) or course (secondary) (15 to 50 per grade/course): Alabama, Mississippi, North Carolina, Ohio, Texas, Utah, Virginia.

Science Frameworks: (n = 28)

- Content statements cutting across K-12 grades (5 to 15 statements): Arizona, California, Florida, Idaho, Indiana, New Hampshire, Wyoming.

- Content by grade cluster (20 to 50 per cluster): Connecticut, Kansas, Massachusetts, Michigan, Nevada, Pennsylvania, Washington, Wisconsin.

- Content by grade (elementary) or course (secondary) (10 to 50 per grade/course): Alabama, Georgia, New Jersey, North Carolina, Ohio, Tennessee, Utah, Virginia, West Virginia.

Combined Math/Science Frameworks: (n = 8)

- Content statements cutting across K-12 grades (5 to 15 statements): Colorado, Kentucky, North Dakota, New Mexico, New York.

- Content statements by grade cluster (20 to 50 per cluster): District of Columbia, Nebraska.

- Content statements by grade or course (10 to 50 per grade/course): Oklahoma.

Clarity and consistency in language are important.

The organization of content standards or statements provides one dimension for examining how state frameworks are written and organized, that is, whether standards are written broadly across grade levels to try to relate content and curriculum among the grades and courses. However, states in the same categories, as listed previously on number and organization of standards, differ widely on other dimensions, such as levels of detail below the main standards or extent of explanation of standards. For example, among mathematics frameworks with standards that cut across K-12, California and New Jersey provide explanation of standards, examples, and discussion of implementation and classroom practices at different grade levels. Maryland and Wyoming mainly express broad goals for mathematics, with little detail, explanation, or discussion of implementation. Arkansas, Louisiana, and Minnesota provide further levels of detail about content in the form of curriculum objectives and desired student skills and knowledge at specific grade levels.

The level and style of writing, use of graphics, and organization and format of the framework should be appropriate for the intended audiences. How the framework is organized and presented can be a key factor in initially inviting use of the framework and in readers returning to the document for further use. Understanding of new concepts and approaches is likely to be increased by use of explanatory paragraphs and examples, but not through use of lists to present content. The following are examples of frameworks with clarity in language and format that appears appropriate for intended users: Massachusetts mathematics and Florida science (see Florida example in Exhibit 3).

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Exhibit 3 Examples of Clarity in Language

Science for All Students: The Florida PreK-12 Science Curriculum Framework, (p. 20-21)

STRAND 4. PROCESSES THAT SHAPE THE EARTH

The physical laws that have governed the entire universe in the past are the same ones that govern material interactions today. Understanding and applying these laws to geological processes provide insight into how Earth formed, how it has evolved, and how it continues to change. Through our study of Earth, we can determine the potential for our future survival.

Areas of Focus:

- Earth is a unique planet in our solar system. It has four major interacting components: lithosphere (earth), atmosphere (air), hydrosphere (water), and biosphere (life).
- Earth systems are interactive, for example, the present atmosphere was created and is maintained by the photosynthetic process of green plants over billions of years.
- Earth's fundamental planetary processes involve cyclical interaction between and among four major systems: tectonic, rock, hydrologic, and atmospheric.
- Decision-making with regard to Earth systems affects the quality of life for all its inhabitants.

ELEMENTARY (K-5)

What should all *elementary students* know about processes that shape the earth?

The Earth's surface is in a continuous state of change. The solid materials making up the Earth come in all sizes, from boulders to grains of sand. Large rocks can be broken down into smaller rocks, which in turn can be broken down to combine with organic material and form soil. Waves, winds, and ice change Earth's surface to produce many features of the land such as cliffs, deserts, and shorelines. Wind and water move soil downstream and deposit it. The water cycle of rain and evaporation is influenced by weather and the shape of the land.

Here are some examples of what all *elementary students* should be able to do after studying processes that shape the Earth.

1. Graph daily weather changes. Demonstrate and describe appropriate precautions to take in hazardous weather situations.
2. Designate an area of the school yard in which to record erosion and weathering over a period of time. Where feasible, note seasonal changes and associate them with migrating birds and growing plants.
3. Investigate properties of rocks and minerals and investigate them using hand lenses and microscopes. Develop systems to group minerals and rocks into sets that have similar properties.

Content standards have certain positive attributes.

The expert reviewers identified the following positive attributes of content standards, based on the 23 frameworks they analyzed:

- Standards clearly specify content to be learned and expected skill or capacity with content;
- High expectations are set for student learning for all students;
- Standards should specify the appropriate developmental level for expected knowledge and skills, matched to students' grade range;
- The range of content standards should recommend a challenging curriculum, including higher-order skills.
- The language and format of standards should encourage understanding and use by educators and be written with sufficient detail to be useful in developing local curriculum.

Main categories of recent mathematics and science frameworks are generally consistent with national standards.

The expert teams that reviewed recent frameworks found that state mathematics frameworks show a high degree of consistency with the main content emphases of the NCTM *Curriculum Standards*. The 12 mathematics frameworks that were reviewed organize the mathematics content using three or four grade clusters, generally K-4, 5-8, 9-12 (as in NCTM), and many frameworks use content "strands" to connect the curriculum across grades.

The main headings and categories of the most recent science frameworks reviewed are generally consistent with the content structure in AAAS *Benchmarks* and the draft NRC *Science Education Standards*, according to the review teams. However, fewer science frameworks were completed when these science documents became available in 1993.

Recent mathematics and science frameworks include emphases of instruction and process skills, e.g., problem solving, reasoning, communication, and scientific inquiry, as integral parts of the mathematics or science content, as in the national standards.

Each state framework has a conceptual scheme for categorizing the content of mathematics and science. To examine how frameworks' content sections are organized, Table 6 shows the main content categories and cross-cutting categories or themes of mathematics and science frameworks that have been completed since 1990. The matrix characterizes the way content is conceptualized by states for K-12 mathematics and science. It also shows how frameworks have tried to incorporate content "knowledge" and "process skills" in the recommendations for curriculum content. The information provides a way to see the relative differences in emphases in content, and the emphasis placed on traditional organization of content (e.g., by discipline) versus organization by cross-cutting strands, themes, or goals.

State frameworks in mathematics follow the pattern of the NCTM *Mathematics Standards* in recommending common content categories across grade levels, often called "strands." The connecting

strands show the intended continuity of mathematics content across grade levels. Some frameworks have created larger organizing categories to link the content of each grade-level block (e.g., Arkansas, California, Kansas, Massachusetts, and South Carolina), whereas other frameworks have categories, also based on NCTM, that include the progression from mathematics in elementary grades to high school mathematics (e.g., Idaho, Indiana, Utah, and Nebraska). Common content categories or strands help to suggest the linkages between the curriculum at each grade level and how content and learning can build from one grade to the next. These categories also suggest the common content that should be available to all students, thus moving away from differentiation of curriculum by student ability or achievement.

Patterns of major mathematics content categories across the 16 math frameworks and seven combined frameworks in Table 6 confirm states are broadly consistent with NCTM standards. **The following numbers of mathematics frameworks have common content categories:**

- 23 of 23 — Number sense/systems, Geometry, Measurement, and Algebra/functions;
- 22 of 23 — Statistics/probability;
- 20 of 23 — Problem solving/thinking skills/reasoning;
- 18 of 23 — Communications and Connections.

Content strands applied across grade levels can help educators plan curriculum that begins building in "higher-order skills" in early grades, along with development of "basic skills." At the next level of detail, frameworks typically show how the common categories or strands increase in complexity at higher grade levels. State frameworks also typically have cross-cutting categories (sometimes called themes or processes) that recommend expectations or skills of students (e.g., reasoning, thinking, or communications).

Patterns of major science content categories across the 14 science frameworks and seven combined frameworks in Table 6 confirm states are generally consistent with emphases of the national reports with some exceptions. **The following numbers of science frameworks have common content categories:**

- 16 of 21 — Nature of science/scientific inquiry
- 13 of 21 — Science processes/skills
- 15 of 21 — Themes across science disciplines
- 12 of 21 — Life science, Earth science, Physical science (across grades)
- 10 of 21 — Applications

Mathematics content needs consistency to detail level.

The expert review teams found that below the major headings and categories for content, mathematics frameworks varied in how consistently the specific content topics or subheadings followed their own vision statement and NCTM *Standards*. "Less consistent" means that sections of the framework that

TABLE 6A

Mathematics Frameworks by Major Content Categories

(N = 16 frameworks since 1990)

5 Strands	*Cross-cutting*
Number sense, properties, & operations	Problem solving
Geometry	Communication
Measurement	Connections
Data analysis, statistics, & probability	Internalizing
Algebra & functions	(using knowledge)

8 Strands	*Cross-cutting*
Functions	Problem solving
Algebra	Communication
Geometry	Reasoning
Statistics & probability	Connections
Discrete mathematics	Unifying ideas are given for 3 grade levels.
Measurement	
Number	
Logic & language	

13 Standards per K-4, 5-8, 9-12	
Problem solving	Patterns & functions
Communication	Algebra (5-8, 9-12)
Reasoning	Trigonometry (9-12)
Connections	Calculus & discrete math (9-12)
Number sense & systems	
Geometry	
Measurement (K-4, 5-8)	
Statistics & probability	
Fractions & decimals (K-4, 5-8)	*Cross-cutting*
Computation & estimation	(Included in standards)

14 Proficiencies per K-4, 5-8, 9-12	*Cross-cutting*
Number sense	Problem solving
Geometry	Communication
Measurement (K-4, 5-8)	Reasoning
Estimation	Connections
Statistics & probability	Interactive learning
Fractions & decimals (K-4, 5-8)	Use of technology
Computation	Assessment
Patterns & functions	
Algebra (5-8, 9-12)	
Trigonometry (9-12)	
Calculus (9-12)	

4 Focus Areas	*Cross-cutting*
Number sense & systems	Essential skills
Patterns, functions, algebraic concepts, & relationships	Communication
	Thinking skills
Geometry & spatial sense	Work independently & in groups
Probability & statistics	Physical & emotional well-being

4 Clusters	*Cross-cutting*
Number sense	Problem solving
Patterns, relations, & functions	Communication
Geometry & measurement	Reasoning
Probability & statistics	Connections

10 Learner Outcomes	*Cross-cutting*
Problem solving	*(Included in outcomes)*
Communicating	
Reasoning	
Value math as integrated knowledge	
Computation & estimation	
Number relationships and functions	
Patterns, relationships & number operations	
Geometric & spatial relationships	
Measurement, statistics, & probability	
Technology	

22 Skills	
Numeration & number theory	Consumer math
Whole numbers	Fundamental math
Fractions & mixed numbers	Algebra I
Decimals	Unified geometry
Ratios & percents	Algebra II
Money, time & measurement	Advanced math
Problem solving	Trigonometry
Geometry	Analytic geometry
Integers, graphing, graphs, tables & charts	Algebra III
Functional literacy skills	Pre-calculus
General mathematics	Calculus
	Cross-cutting
	None indicated

Mathematics Frameworks by Major Content Categories (cont.)

[redacted]

8 Goals and Standards	*Cross-cutting*
Problem solving & reasoning	*(Included in goals/*
Communication & connections	*standards)*
Numbers, numeration & number theory	
Geometry, measurement, & trigonometry	
Data analysis, statistics, & probability	
Functions, relations, & algebra	
Mathematics of change	
Discrete mathematics	

[redacted]

Content Standards	*Cross-cutting Process*
Number sense	Problem solving
Spacial sense	Communication
Numerical operations	Reasoning
Measurement	Connections
Estimation	
Patterns, relationships, & functions	*Learning Environment*
Probability & statistics	Equity
Algebraic concepts & processes	Positive perception
Discrete math	Use of technology
Calculus	Assessment

Ohio

8 Strands	*Cross-cutting*
Patterns, relations, & functions	Thinking
Problem solving	Development
Numbers & number relations	Technology
Geometry	Connections
Algebra	Communication
Measurement	
Estimation & mental computation	
Data analysis & probability	

South Carolina

6 Strands	*Cross-cutting*
Number & numeration systems	Problem solving
Numerical & algebraic concepts	Communication
& operations	Reasoning
Patterns, functions & relationships	Connections
Geometry & spatial sense	
Measurement	
Probability & statistics	

[redacted]

Course Outlines (9–12)	*Cross-cutting*
Arithmetic 9	*None indicated*
Applied Math I	
Pre-Algebra	
Algebra I, II	
Unified Geometry	
Math IV	
Trigonometry	
Probability & statistics	
Pre-calculus	
Calculus	

[redacted]

7 Essential Eements (grades 1–8)	*Grades 9–12, Organized by Course*
Problem solving	Fundamentals of math
Patterns, relations, & functions	Consumer Math
Number & numeration concepts	Algebra I
Operations & computation	Algebra II
Measurement	Geometry
Geometry	Trigonometry
Probability, statistics, & graphing	Calculus
	Cross-cutting
	None indicated

Utah

Standards	
Logical reasoning	Fractions & decimals
Estimation	Patterns
Number meanings	Number representations
Number operations	Number systems
Computation	Algebraic concepts
Geometry	Probability methods
Measurement	Algebra
Data sets	Applied math
	Cross-cutting
	None indicated

West Virginia

12 Instructional Goals	
Problem solving	Algebra
Communications	Statistics & probability
Reasoning	Geometry
Connections	Measurement
Number & number relations	
Number systems & theory	*Cross-cutting*
Patterns & functions	*(Included in goals)*

Source: Council of Chief State School Officers, Study of State Curriculum Frameworks in Mathematics and Science, 1995.

TABLE 6B

Science Frameworks by Major Content Categories

(N = 14 frameworks since 1990)

3 Content Areas	*Cross-cutting*
Physical sciences	Energy
Earth sciences	Evolution
Life sciences	Patterns of change
	Scale and structure
	Stability
	Systems & interactions

3 Areas of Objectives	*Cross-cutting*
Life Science	Attributes & attitudes
Physical science	Skills & competencies
Earth & space science	Understandings & applications
	In addition, seven overriding goals for achievement are listed.

8 Strands	*Cross-cutting*
Nature of matter	Scientific knowledge
Energy	Conceptual themes
Force and motion	Attitudes
Processes that shape the earth	Processes
Earth and space	
Processes of life	
Interaction with the environment	
Nature of science	

3 Disciplines	*Cross-cutting Outcomes*
Life science	Knowledge
Earth science	Process skills
Physical science	Application

Curriculum Guides by course/grade level (e.g. Earth Science, Grade 8)	*Cross-cutting*
Main Concepts	**Process Skills**
Introduction to Earth science	Observing
Matter	Inferring
Lithosphere	Classifying
Atmosphere	Using numbers
Hydrosphere	Measuring
Energy Resources	Using space/time relationships
Pollution	Communicating
Astronomy	Predicting

4 Program Outcomes	*Cross-cutting*
Nature of science	Matter & energy
Meaning of science	Patterns of change
Integration of science	Systems & interactions
Relationship of social, technological & scientific issues	Stability
	Models

4 Content Areas	*Cross-cutting*
Science as inquiry	The framework is organized thematically, emphasizing the cross-cutting nature of science teaching and learning.
Science subject matter	
Technological design	
Science and human affairs	

3 Areas of Objectives	*Cross-cutting*
Life science	Dimensions of scientific literacy
Physical science	Categories of scientific activities
Earth & space science	Connecting themes

5 Concept Areas	*Cross-cutting*
Overarching concepts	Cause and effect
Process skills	Change
Personal Needs	Cycles
Science in the world	Energy & matter
Reading and writing in the world	Equilibrium and homeostasis
	Interaction
	Fundamental entities
	Probability
	Patterns & symmetry
	Systems

4 Objectives	*Cross-cutting*
Scientific habits of mind	*None indicated*
Positive attitude in science	
Integration of science, technology, society, and environment	
Key concepts and principles	
Secondary Science is organized by course.	

Science Frameworks by Major Content Categories (cont.)

6 Curriculum Strands	*Cross-cutting*
Science as inquiry	*(Included in strands)*
Science, technology, and society	
Life science	
Earth/space science	
Physical science	
Unifying themes and concepts	

5 Goals	*Cross-cutting*
Nature of science	Scientific inquiry
Physical setting	Scientific knowledge
Living environment	Conditions for learning science
Societal perspectives	Applications for science learning
Thematic ideas	

3 Science Concepts	*Cross-cutting*
Earth/environmental science	Nature of science
Life science	Process skills
Physical science	Manipulative skills
	Attitudes toward science
	Concepts
	Unifying concepts
	Forces, Time
	Matter, Space
	Energy, Motion

Standards by grade (K–6) and course (7–12). E.g., Grade 6:	*Cross-cutting*
Heat, Light, sound	Basic inquiry skills
Astronomy	Integrated inquiry skills
Solar system	Scientific attitudes
Microorganisms	Awareness of science
	Science concepts, principles, & systems
	Communication
	Nature of science

Source: Council of Chief State School Officers, Study of State Curriculum Frameworks in Mathematics and Science, 1995.

TABLE 6C

Combined Mathematics and Science Frameworks by Content Categories

(N = 7 frameworks since 1990)

6 Science Content Standards	*Cross-cutting*
Investigations	**Science**
Matter and energy	Scientific investigations
Living things	Scientific applications
Earth and space	Connections
Applications	
Connections	
6 Mathematics Content Standards	**Mathematics**
Numbers	Problem solving
Algebraic methods	Communication
Data collection, analysis, statistics, & probability	Reasoning
	Becoming confident
Geometric concepts	Learning the value of mathematics
Tools & techniques	
Computational skills and techniques	

3 Science Content Strands	*Cross-cutting*
Life science	**Science**
Physical science	Energy
Earth science	Systems
	Stability
	Patterns of change
	Evolution
	Scale & structure
7 Mathematics Content Strands	**Mathematics**
Number sense & estimation	Problem solving
Number systems	Communication
Patterns, relationships, & functions	Reasoning
Geometry & spatial sense	Connections
Measurement	
Probability & statistics	**Technology**
Algebraic concepts & operations	Involve students
	Develop positive attitudes
Technology	Integrate science & mathematics
No strands are listed	

6 Science Themes	*Cross-cutting*
Scientific skills	**Science**
Patterns	Progress from concrete to abstract
Systems	Explore topics
Models & scale	Commect concepts
Constancy	Include interdisciplinary studies
Evolutionary change	
7 Mathematics Core Concepts	**Mathematics**
Number	Learn to value math
Procedures/operations	Become confident
Space & dimensionality	Problem solving
Measurement	Communication
Change	Reasoning
Mathematical structure	Become self-sufficient learner
Data concepts (probability & statistics)	Become responsible group member
	Think
	Connect and integrate knowledge

6 Science Strands	*Cross-cutting*
Matter	**Science**
Force & motion	Energy
Universe	Patterns of change
Diversity	Scale & structure
Cells & heredity	Systems & interactions
Interdependence	
8 Mathematics Strands	**Mathematics**
Number sense	Estimation
Measurement	Problem solving
Spatial relationships/geometric topics	Technology
Data analysis	Communication
Patterns & functions	Connections
Algebraic topics	Reasoning & logic
Discrete mathematics	
Advanced Topics	

Combined Mathematics and Science Frameworks by Content Categories (cont.)

6 Science Content Outcomes	***Cross-cutting***
Nature of science	*None specified*
Systems	
Patterns	
Energy & matter	
Cause & effect	
Models	
8 Mathematics Content Outcomes	
Number concepts	
Geometric concepts	
Patterns, relationships, & algebraic concepts	
Data analysis, probability, & statistical methods	
Number systems & theories	
Trigonometry	
Discrete structures	
Calculus	

3 Science Applications	***Cross-cutting***
Earth/space science	**Science Skills**
Life science	Observing & Measuring
Physical science	Classifying
	Experimenting
	Interpreting
	Communicating
	Safety in the Science Class
8 Mathematics Content Skills	**Mathematics Process Skills**
Number Sense & Number Theory	Problem solving
Computation & Estimation	Communication
Patterns & Functions	Reasoning
Algebraic Concepts	Connections
Statistics	
Probability	
Geometry	
Measurement	

9 Standards in Science, Mathematics and Technology	***Cross-cutting***
Analysis, inquiry, & design	Integration across disciplines
Systems	Contextually appropriate
Information resources	Content competency
Connecting themes	Correspondence between assessment & standards
Interdisciplinary problem solving	
Preparation for the future	
Physical setting, living environment, human organism	
Technology	
Logic, number sense, geometry, measurement, probability & statistics, algebra	

Source: Council of Chief State School Officers, Study of State Curriculum Frameworks in Mathematics and Science, 1995.

provide greater levels of detail show less evidence of key concepts and connections that are central to the NCTM Standards. For example, state recommendations for problem solving and communication were sometimes not well connected to content areas such as geometry or measurement; examples or illustrations can show educators what is meant by teaching geometry as problem solving. As another example, broad state recommendations encouraging use of calculators in mathematics were not always followed with specific strategies or steps for integrating calculators in class and on tests, which can send a mixed signal to mathematics educators.

The emphasis in NCTM *Standards* on problem solving, connections, and conceptual understandings is typically more clearly expressed for grades K-4 and 5-8, than for grades 9-12 where traditional approaches to content tend to remain. Frameworks are often not explicit on how the range of 9-12 standards, including algebra, geometry, trigonometry, statistics and probability, and functions, will be taught to all students. One indicator of change is that consumer mathematics or general mathematics courses for grades 9-12 are consistently excluded from state frameworks. The following is one example of a mathematics framework with consistency at the more detailed level for high school curriculum level: California mathematics framework (see Exhibit 4).

Science frameworks differ from national standards in several areas.

The majority of science frameworks reviewed by expert teams were written before the publication of the AAAS *Benchmarks* or the draft NRC *Science Education Standards*, and states had a less well-defined set of guidelines to use in developing their frameworks' science standards, compared to their mathematics standards. As a result, science frameworks developers determined their own combinations of scientific content or built on what was available from other state frameworks or earlier national reports. **Some states left key content areas out of their frameworks that AAAS and NRC eventually included, giving less emphasis to the nature of science, history of science, science as inquiry, science and society, and science applications.** In some frameworks, these areas are mentioned but are not recommended as content standards. States may want to refer to the two national documents and examine how these areas of science standards are treated.

Framework components should have a consistent approach.

The review teams saw internal consistency as a key ingredient of frameworks—for example, if a framework's vision for mathematics calls for five to six main content strands that are aimed at integrating content across the grades, then the framework's recommended content standards at different grade levels should be consistent in recommending integrated math content. Suggested curriculum development strategies, including model units or lessons, should follow the same ideas to help demonstrate how a strand is developed. Vignettes and examples can provide a real-life grounding to the vision, strands, content, and strategies that have been laid out. Inconsistency among framework components may be a problem in state framework design: Framework development is often carried out by individuals and committees with different expertise. The following are examples of frameworks that show high consistency across sections: California mathematics, Massachusetts mathematics and science, and Nebraska mathematics and science (see Exhibit 4 for examples of sections of these frameworks).

Science themes can bridge traditional subject areas.

The science disciplines are used to organize science content in most state frameworks (e.g., earth science, life science, physical science). However, in the view of the review teams, these subject disciplines often do not represent how science is actually done by scientists, and they do not reflect emphasis in the national standards on how curriculum should be implemented in the classroom. For example, the study of acid rain involves life, physical, and earth science. The NRC Science Standards and AAAS Benchmarks include science themes, or unifying concepts, such as systems, models, change, measurement, or scale, as ways to understand the world and strategies for connecting content areas. State framework developers have found it challenging to use themes to make connections across the disciplines and grade levels, and to incorporate active learning instructional methods. Examples of state frameworks that make effective use of themes to link content and to bridge between state and national content standards and local curriculum development: Nebraska mathematics and science framework and California science framework (see Exhibit 5 for examples from these frameworks).

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Exhibit 4, pg. 1 — Examples of Internal Consistency

Mathematics Framework for California Public Schools, K–12

Vision

Reform is necessary. In current programs too few young people leave school mathematically powerful. To address this problem, this *Framework* asks that teachers and students raise their expectations and expand their vision of what can happen in a mathematics classroom and what can appear in mathematics instructional materials. *All* students are capable of the level of work described here, but time, hard work, and courage will be needed to make this vision a reality. *(p. 2)*

Content of the High School Program

Strands

Functions
Algebra
Geometry
Statistics and Probability
Discrete Mathematics
Measurement
Number
Logic and Language

Unifying Ideas

Mathematical Modeling
Variation
Algorithmic Thinking
Mathematical Argumentation
Multiple Representations
(high school version of the middle grades unifying idea)

Suggested Units for the High School Grades

Representing and Analyzing Physical Change Over Time
Measuring Inaccessible Distances
Families of Functions
Mathematics of Geometrical Solids
Looking Back at Triangles
Secrets and Information: Encryption and Decryption

(p. 141)

Unifying Ideas for High School

The mathematical content for high school must be organized to develop depth as well as breadth. For depth to be achieved, a small number of unifying ideas must be chosen as priorities for the core program.

Mathematical modeling. Mathematical modeling enables students to appreciate the power of mathematics to help them understand the world. (p. 158)

Variation. How is a *change* in one thing associated with *change* in something else? ... Thinking in terms of *variation* can help students use the idea of related changes to understand mathematical relationships. An increase in one quantity results in an increase (or decrease) in another. (p. 159)

Algorithmic thinking. The traditional school mathematics curriculum has justifiably been criticized for overemphasis on the memorization and rote application of algorithms. If the focus is placed instead on the process of *developing, interpreting,* and *analyzing* algorithms, students can develop insight into the nature of mathematics. (p. 161)

Mathematical argumentation. Mathematical argumentation helps students answer questions, for example: "How do I know when I'm right?" "Is this statement *always* true?" "Is it possible to satisfy these conditions?" (p. 162)

Multiple representations. ...
(p. 131) Students are helped to clarify questions and situations, evaluate solutions, make mathematical connections, and elucidate underlying structure. (p. 163)

Use of Example

Overview of "Do Bees Build It Best?"

In this unit students work on the following problem:

Bees store their honey in honeycombs, which consist of cells they make out of wax. What is the best design for a honeycomb?

Students learn about the meaning of *area,* including the idea of a *unit.* They discover some basic formulas for calculating the area of specific shapes. Then they learn about the Pythagorean theorem. Using that theorem and the trigonometry that they learned in the first year's curriculum, students find a formula for the area of a regular polygon with a fixed perimeter. The formula is written in terms of the number of sides. Using the graphing facility on their calculators, students discover that the larger the number of sides, the larger the area. The circle is a limiting figure for the sequence of regular polygons having a fixed perimeter.

Students turn their attention to volume, using an approach similar to that used with area. They focus on the volume of prisms with regular polygons as bases. Then they find that the question *Which prism has the largest volume for a fixed lateral surface area?* reduces to the question *Which prism has a base with the largest area for a given perimeter?*

Using their earlier findings on regular polygons, students see that cylinders might be a candidate for the best bee cell. This candidate is rejected because cylinders leave gaps when they are fitted together. Students then look at the question *Which prism that has a regular polygon as a base and tessellates (i.e., leaves no gaps) will have the largest volume for a fixed perimeter?*

They find that cells in the shape of regular hexagonal prisms, the choice of the bees, are the mathematical winner if they consider only prisms with regular polygons as bases. Students conclude the unit by watching the video titled *The Mathematics of the Honeycomb* and discussing other candidates for cells besides prisms and other bases besides congruent regular polygons. *(p. 164)*

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Exhibit 4, pg. 2 Examples of Internal Consistency

Massachusetts Curriculum Framework for Mathematics and Science

Vision

Envision a society whose members understand and appreciate the value of science and mathematics–a society where the people have the knowledge, positive attitude and technological skills to contribute new ideas in a complex world. Envision schools where all learners–not just those who aspire to be scientists or mathematicians–discover the power of mathematics, science and technology and develop the ability to reason scientifically and mathematically as they investigate and solve complex problems using the tools they need.

(p. 1)

Example

Pioneer Valley Regional School: Making Connections Work

At our school, most of us teach both junior and senior high classes in the course of the day. We also have a rotating schedule and heterogeneous class groupings. When the science and math teachers began to look at more interdisciplinary work, they decided to succeed despite the rigid schedule. They both had the same students over the course of the combined unit that involved using the school grounds to collect data for a science project, and the students then needed their math to organize, graph, and analyze their data. For the duration of the project, the students brought their math and science materials to both scheduled classes. One day the math teacher would be the contact person in the two adjoining classrooms, while the science teacher was out on the grounds with the data gatherers. On another day, the teachers would switch. On any given day, the students felt comfortable asking math or science questions of either teacher. If you asked students if they were doing math or science, their answer would simply have been, "Yes!"

(p. 33)

Content Standard

Mathematics as Connections

In grades 5-8, the mathematics curriculum should include the investigation of mathematics connections so that students can -

- see mathematics as an integrated whole;
- explore problems and describe results using graphical, numerical, physical, algebraic, and verbal mathematical models or representations;
- Use a mathematical idea to further their understanding of other mathematical ideas;
- apply mathematical thinking and modeling to solve problems that arise in other disciplines, such as art, music, psychology, science, and business;
- value the role of mathematics in c culture and society.

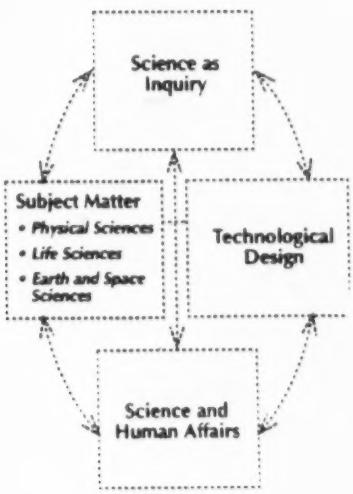
(p. 55)

Life Science and NCTM Standard "Patterns, Relations, and Functions"

A group of first-graders is studying life science at the ocean, and visits the beach to collect shells. Back in the classroom, students sort the shells in different ways: by characteristics of bumpy/smooth, color, shape; and then by families such as clams and snails. They make frequency graphs in order to answer the question: What are the most common kinds of shells? Are they the same for every beach? What is the average size of each kind of shell? Or is there a range of sizes? Do the patterns change at different seasons? Why might that happen?

(p. 33)

Content Organization



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Examples of Internal Consistency

Mathematics & Science Frameworks for Nebraska Schools

Vision

The mission of the Mathematics/Science Framework is to provide guidance and support to enhance learning for all students in the state of Nebraska.

Beliefs

All students can learn science and mathematics, given support and opportunity.

Science and mathematics are an integral part of everyday life.

Learning mathematics and science requires active participation.

Science and mathematics instruction must be relevant, student oriented, and process driven to accommodate the needs of a changing world.

Connections must be made within mathematics and within science as well as across disciplines.

Learners must be empowered to think and learn for themselves.

(p. viii)

Content Standard

Primary Forces and Motion *(Primary Science)*

Primary students recognize that objects move—people, swings, cars, birds, clouds, the sun—in many different ways. Motion-related phenomena such as starting, stopping, falling, and changing direction are explained by force. Force is the name given to a push or pull. Magnetism is interesting to children because it is a force that they can observe and experiment with. The concept of gravity can be investigated by observing its effects on students and common objects. Children should be introduced to technology, familiar machines, and energy consumption.

Energy should not be introduced as a scientific idea at this time. "The idea that is accessible at this age is that keeping anything going uses up some resource" (AAAS, 1993, p. 83). It is also appropriate for children to explore light, heat, sound, and electricity—all facets of energy.

Measurable Performances

The learner will:

- Observe and describe motion of familiar objects.
- Describe how the use of a familiar machine or technology improves life.
- Demonstrate how forces can be used make objects interact, move, stop, or change directions.

A Closer Look

Learning about energy and forces should be experiential. Students should be provided with a variety of experiences involving motion, what causes objects to move or, what causes an object in motion to change speed or direction. Materials for informal observation activities include batteries, bulbs, wire, switches, bells, magnets, nails, balls, toy cars, ramps, and old, unusable machines. Sound waves and vibration may be introduced by the use of drums, bells, strings, etc. *(p. F-3)*

Example

Making the Best Better
Primary Science

Sample Investigation #1

Children's books featuring the insides of machines and their cross-sections may be used to accompany these activities. Have students bring used machines of every kind (check first for unsafe parts and remove electrical cords). Set up a tinkering center equipped with screwdrivers, wrenches, safety glasses, pliers, and other appropriate tools. Once the machine is dismantled, components can be used for observation, graphing, and comparison activities. *(p. F-4)*

Sample Investigation #2

Investigate how variables influence the movement of matchbox cars. For example, explore how the speed of matchbox cars are influenced by changing the inclined ramp, height, and surface.

Sample Investigation #3

Observe, record, and describe interactions of toys, playground equipment, and animals.

Sample Investigation #4

Discuss and illustrate appropriate choice of transportation for various activities.

Sample Investigation #5

Use dismantling of used machines for graphing. Classify machine parts (e.g., screws, washers, fuses, magnets). Graph results of investigation. *(p. F-4)*

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Exhibit 5, pg. 1 Examples of Using Science Themes

Mathematics & Science Frameworks for Nebraska Schools (p. E-1)

Making the Best Better

Science

Science Framework

The K-12 Science Framework is divided into four levels: primary (K-3), upper elementary (4-6), middle (7-8), and secondary (9-12). Since Nebraska has no standard grade clusters within school districts, the broader terminology of levels is used throughout the document to provide the flexibility needed to accommodate Nebraska schools.

Conceptual Threads in Science Frameworks

In addition to the topic strands, the Framework uses four unifying threads: energy, patterns of change, scale and structure, and systems and interactions. The threads interact with the topic strands. The threads and scientific processes are integrated throughout the topic strands. These threads are applied to and repeated within the study of each topic. This repetition of instruction is vital for conceptual learning. As learners progress through developmental stages, both topics and threads are revisited. Thus, vertical objectives for growth are implemented and spiraling curriculum is constructed. Because each conceptual thread is contained in the Frameworks but not separately mentioned, a short definition is given.

Science

OVERVIEW OF K-12 SCIENCE

TOPIC STRANDS	CONCEPTUAL THREADS				
	LEVELS	PATTERNS OF CHANGE	ENERGY	SYSTEMS & INTERACTIONS	SCALE & STRUCTURE
MATTER	Primary	Investigate properties of solids, liquids, and gases	Explore relationship between energy and phase changes	Explore effect of physical treatments on matter	Construct large objects from smaller parts Informally use concrete activities to develop a sense of relative size
	Upper Elementary	Investigate physical properties of matter	Investigate effect of temperature on physical and chemical changes	Explore physical and chemical interactions of matter	Discover the whole equals the weight of the sum of the parts
	Middle Level	Compare and contrast properties of reactants and their compounds	Experiment to discover that energy is involved in chemical and physical changes Relate energy of motion to phases	Predict chemical interactions using the periodic table Investigate effect of temperature and pH on reaction rates	Connect the idea of atoms to conservation of matter
	Secondary	Predict mathematical relationships from data Relate periodicity to properties of matter Explore radioactive decay rates	Analyze efficiency of energy transformations	Investigate effect of variables on reaction rates Relate electron configuration to chemical interactions	Compare atomic/molecular structure with their properties

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Exhibit 5, pg. 2 Examples of Using Science Themes

Science Framework for California Public Schools, K-12, (p. 27)

Six themes, explained in the following pages, are developed in this framework. They are:

1. Energy
2. Evolution
3. Patterns of Change
4. Scale and Structure
5. Stability
6. Systems and Interactions

The presentation of science could be organized along other thematic lines; possibilities include actions, reactions, interactions, matter, diversity and unity, hierarchy, energy and matter, and many others. While the particular configuration and number of themes is not crucial, the organization of content along thematic lines is.

Educators and developers of instructional materials are encouraged to weave these or alternative thematic strands into science curricula. The main criterion of a good theme is its ability to integrate facts and concepts into overarching constructs; thus, diversity and unity would make a good theme; conversation, applied to biology or physics, might also. Dinosaurs or apples, no matter how diversely or inventively used, are not themes in the sense described here.

Example of a theme progressing through the grades *(p. 154):*

EVOLUTION

Kindergarten Through Grade Three

The Processes: Observing, Communicating, Comparing, Ordering, Categorizing

Sample Content: Living things have identifiable characteristics; there is great diversity among living things.

Grades Three Through Six

The Processes: Observing, Communicating, Comparing, Ordering, Categorizing, plus Relating

Sample Content: Living things are adapted to their environment for survival; various structures of living things operate in ways that keep them alive and growing.

Grades Six Through Nine

The Processes: Observing, Communicating, Comparing, Ordering, Categorizing, Relating, plus Inferring

Sample Content: Evolution includes a process whereby living things are naturally selected from generation to generation, producing descendants with different characteristics; through geologic time, evolutionary processes have shaped the forms and adaptations of all the species of plants and animals now living, as well as others that have become extinct.

Grades Nine Through Twelve

The Processes: Observing, Communicating, Comparing, Ordering, Categorizing, Relating, Inferring, plus Applying

Sample Content: Worldwide agreements must be made for the preservation of resources and species. The characteristics of living things can be altered through manipulation of the DNA structure.

Communication of Content

The recommended content statements or standards in a state framework may constitute a new or "reform" approach to mathematics or science curriculum and instruction. A major question examined by the CCSSO study was whether and how the framework provides teachers, administrators, or local mathematics/science specialists with explanations, examples, or models to increase understanding of the approach and to aid in curriculum development. One way to view this question is to examine how the state document acts as a bridge between national standards and the development of local curriculum and instruction.

States have often actively guided curriculum, instruction, and resource/materials selection. What is unique about the recent frameworks is the degree to which they integrate education policies into a readable set of guidelines that communicate with educators, state and local policymakers, and citizens about those policies. The new frameworks show something of the relationship among education policies in the state. NCTM provided national and state policymakers with the first example of this policy and content integration. The *Standards* articulated a clear philosophy of teaching and rigorous new expectations for students, teachers, and communities. Following the publication of the NCTM *Standards*, it became clearer how state frameworks might be similarly constructed, to establish new expectations for student achievement and for teaching. Thus, the new frameworks are resources demonstrating a different vision of student learning in mathematics and science. Although frameworks center on redefining curriculum and instruction, they also address assessment, professional development, and technology, among other areas of curriculum reform. Many new elements are included in the curriculum frameworks, including comprehensive standards of what mathematics and science must be taught and what the expectations are for children's learning.

Examples help to demonstrate intended content.

The CCSSO analysis identified methods of presenting and illustrating the content standards used in frameworks. We were interested in how frameworks are structured to try to increase understanding, or, put another way, how they tried to be "user-friendly" in assisting educators with developing and implementing content.

CCSSO found that the use of examples, vignettes, and strategies allows the framework to make the vision and content recommendations concrete and explicit. They also provide the educator with a fuller understanding of the underlying approach to content and instruction. For example, if the state is trying to promote an approach to science education emphasizing the development of knowledge through reasoning and problem solving, the framework can illustrate a practical application from a school and classroom within a specific content area. Vignettes and examples also can show the importance and use of tools (e.g., calculators, computers, balances, thermometers, and laboratory equipment). For example, California presents ideas and examples of ways to integrate calculators into mathematics learning in various content areas. The following are frameworks that made good use of examples: Kentucky integrated, Minnesota science, Florida science, and Nebraska math-science (see examples in Exhibits 4, 6, 7, 8, 9). The following are frameworks that illustrate the use of vignettes: New Jersey mathematics standards, Massachusetts mathematics and science, Ohio mathematics and science (see Appendix F for samples of some of these vignettes).

The conceptual-mapping process provided information on which frameworks use specific methods of presenting and explaining content through models, examples, or instructional activities and use diagrams,

graphics and photos to communicate key ideas about content. During the development and review process, states identify needs of educators. For example, Florida's framework developers learned that local curriculum specialists and teachers found it difficult to read, interpret, and then apply a wide variety of mathematical or scientific concepts to curriculum development without having some commonly understood examples of practice. The Florida framework needed to use examples to link new concepts and approaches to ideas teachers already may have known about but were unsure of how to teach.

Table 7 shows the methods of communicating content that were identified in the 60 frameworks analyzed in the study. The analysis of content was divided according to frameworks completed since 1990 and frameworks completed in 1990 or before that date. The patterns for the two groups of frameworks show clearly that recent frameworks are providing more ways to present and communicate subject content recommendations and suggestions. The following are some of the features of the more recent frameworks:

- **Examples/models:** In total, 19 of the 40 frameworks since 1990 provide examples or models that give "how to" illustrations that show the application of mathematics or science content in classroom practice. For the older frameworks, only two of 20 frameworks provided any models or examples that illustrate how content would be applied.

- **Activities/tasks:** Twenty-one of 40 frameworks since 1990 suggest or recommend student activities or teaching practices in the framework, and these activities typically were listed or outlined with little detail about how the practice could be applied within classrooms. Among frameworks completed in 1990 or before, nine of 20 frameworks provided an outline or lists of classroom activities or tasks.

- **Vignettes:** Vignettes were defined in the analysis as illustrative classroom scenarios or essays that describe teaching, situating instruction in a context that demonstrates give and take among children and teachers and shows with considerable detail how teachers define in practice specific content areas and instructional approaches. This form of communicating content to educators provides a way for a framework reader to see the combination of factors involved in implementation of high content standards, such as those envisioned by NCTM and NRC. Vignettes can show the combination of classroom organization, instructional practices, teacher knowledge, student involvement, materials and resources, and application of equity principles, as well as curriculum content. Of the 40 recent frameworks, seven provided at least one vignette that provided a detailed example of implementation (see Appendix F for sample vignettes). Only one of the 20 frameworks from 1990 or earlier included vignettes.

- **Diagrams, graphics, photographs:** The use of visual material, such as diagrams, graphics, or photographs, can help to portray, highlight, or illustrate instructional activities, tools, patterns, or relationships among areas of content and instruction. A total of 18 of 40 frameworks since 1990 used some visuals, whereas only four of 20 frameworks from 1990 or earlier used any visuals.

  Note: A state may have methods of communicating mathematics and science content standards and instructional practices that address recommended content but that are not in the framework. Other publications, materials, or activities may be in place to provide assistance or suggestions to educators, schools, and districts. The CCSSO study analyzed only those methods or practices covered in the curriculum framework itself.

TABLE 7

Methods of Presenting and Communicating Content in Framework

(N = 40 frameworks since 1990, 20 frameworks 1990 or before[1])

MATHEMATICS *Frameworks post-1990*

Features by State	AR	CA	ID	IN	KS	MA	MN	MS	NJ	NV	NC	SC	TN	TX	UT	WV	Total
Vignettes						◆			◆								
Examples/models	◆	◆	◆	◆	◆	◆			◆		◆	◆					
Activities/tasks		◆		◆	◆	◆	◆					◆					
Diagrams/graphics		◆	◆	◆	◆	◆	◆					◆					

Frameworks pre-1990

Features by State	AL[2]	GA	MD	MI	OH[2]	VA	WI	WY	Total
Vignettes	◆				◆				
Examples/models			◆						
Activities/tasks			◆				◆		
Diagrams/graphics			◆	◆	◆			◆	

SCIENCE *Frameworks post-1990*

Features by State	CA	CT	FL	IA	IN	KS	LA	MA	MI	MN	MS	MT	NC	NV	OH	UT[3]	Total
Vignettes			◆					◆							◆		
Examples/models	◆	◆	◆	◆			◆	◆				◆			◆		
Activities/tasks	◆	◆	◆	◆	◆	◆		◆	◆	◆					◆	◆	
Diagrams/graphics	◆	◆	◆					◆	◆				◆		◆		

Frameworks pre-1990

Features by State	AL	AZ	GA	ID	MD	NJ	PA	TN	WI	WV	WY	Total
Vignettes												
Examples/models					◆							
Activities/tasks		◆	◆	◆	◆	◆	◆		◆			
Diagrams/graphics												

COMBINED *Frameworks post-1990* *Framework pre-1990*

Features by State	CO	DC	KY	ND	NE	NM	NY	OK	Total	MO
Vignettes			◆		◆					
Examples/models			◆				◆			
Activities/tasks		◆	◆		◆		◆			
Diagrams/graphics			◆		◆	◆	◆			

Vignettes: Illustrative classroom scenarios or essays that describe teaching and show how teachers define in practice specific content areas and instructional approaches.

Examples/models: How to illustrations that show the application of content in classroom practice.

Activities/tasks: Student activities or teaching practices with little detail about how the practice is to be used within classrooms.

Diagrams/graphics: Visuals used to portray, highlight, or illustrate instructional activities, tools, patterns, or relationships.

Source: Council of Chief State School Officers, Study of State Curriculum Frameworks in Mathematics and Science, 1995.

Pedagogy: Translating Standards into Classroom Practice

Changing what is taught in mathematics and science depends as much on renewing the pedagogy—the way the content is taught—as it does on modernizing and advancing the content. Research in mathematics and science teaching has shown that instruction is most successful when it is interactive. The national professional standards encourage teachers to activate learning by engaging students, with their teachers, in experiments, questions, conjectures, and following hunches to see where they lead. Pedagogy in the curriculum frameworks sets the stage for learning. It suggests ways to create environments that encourage students' deliberative thinking about mathematics and science, stimulating the habits of inquiring mathematical and scientific minds.

Instructional emphasis and student skills can be interwoven with content.

The review teams found that state frameworks show marked progress in expanding beyond a basic skills emphasis to instructional emphasis on higher-order skills for all students in mathematics and science, such as expecting students to apply knowledge through problem solving, reasoning, communication, or scientific inquiry. When these emphases are modeled through concrete suggestions, examples, and alternative practices, they reflect the new vision more effectively than when desired skills are presented as lists or objectives separate from content. Simply listing desired skills without some text explaining how they can be interwoven with content tends to diminish their importance. Such lists do not give educators sufficient background and understanding to assist in curriculum development. The following are examples of frameworks that include explanations of thinking and reasoning skills in relation to content: California science, Ohio science (see Exhibit 6 for examples from these frameworks).

Frameworks can assist educators with implementation.

Frameworks can be effective in demonstrating the application of national or state standards in local curriculum. If state frameworks have the purpose of improving mathematics/science education, the review teams saw that they are most successful when they explain through vignettes and examples that build on the existing knowledge base about how to implement such reforms in the classroom. **Important information can be imparted by clearly showing differences between typical classroom practice today and intended practice under the vision of the framework.** The following are examples from frameworks that show the transition in classroom practices: California mathematics, Massachusetts mathematics (see Exhibit 7 for examples from these frameworks).

Nine Core Teaching Strategies

The panel advising CCSSO in study design saw a key role of curriculum frameworks in explicitly connecting learning and teaching to content standards, helping educators understand, interpret, and apply the recommendations of mathematics and science reformers. The CCSSO study identified a core of nine teaching strategies that are discussed by various national standards documents as fundamental to a cognitively rich mathematics and science learning context (NCTM, 1989; AAAS, 1993; NRC, 1994 draft; see Definitions in Appendix B)

- active—or what educators are calling "constructive"—lessons
- technological applications

Exhibit 6, pg. 1 Examples of Content and Student Skills

Science Framework for California Public Schools, K-12, (p. 146-7)

COMMUNICATING
The scientific thinking process that conveys ideas through social interchanges

Most animals are able to communicate in some way with other members of their own species, but humans, more than any other organism, are unique in the ability to create and use language and symbols that convey ideas in the present and preserve those ideas in order to communicate with others in the future.

Scientists communicate through published works, lectures, and conferences. The community of scientists in a given field, reading and studying each other's works, provides a check on the objectivity and accuracy of a scientist's work. Published research is replicated or extended by others interested in the topic.

Teacher's statements and questions that facilitate the process of **communicating:**
"What do you see?"
"Draw a picture of what you see through the microscope."
"Plot the data you gathered on a graph."
"Make a histogram of the number of raisins in slices of raisin bread."
"Write up your experiment so it can be replicated by someone else."
"Summarize your findings and present them to the class."

Inaccuracy or error in the work is quickly discovered.

A histogram, for example, communicates a distribution along a continuum, as in tallying the heights of youngsters in a classroom. A Cartesian graph communicates information that relates one factor to another, as in using the height of a burning candle as a function of time.

Language arts activities and mathematics, with their ways of depicting data, should not be separated from science instruction. The communication skills of one content area enhance the skills of the other.

COMPARING
The scientific thinking process that deals with concepts of similarities and differences

The process of comparing builds on the process of observing. Unfortunately, some peopl confuse the two: "Observe the similarities and differences between these two animals." What they mean to say is: "Compare the similarities and differences."

We can learn about the shape (or color, size, texture) of an object by comparing its shape to those of other objects. Objects are separated or put together on the basis of comparable differences or similarities. When we do this, we develop more complex concepts than with simple observations of these objects. For example, youngsters can conceptualize two distinct types of measurement involving length: (1) length as a property of the object; and (2) length as a linear distance between two objects or points.

Teacher's statements and questions that facilitate the process of **comparing:**
"How are these alike?"
"How are these different?"
"Compare these on the basis of similarities and differences."
"Which is larger/smaller (softer/louder, smoother/rougher, wetter/drier)?"

Science Framework for California Public Schools, K-12, (p. 151)

Table 1 **Matching Science Processes and Content with Children's Cognitive Development, Kindergarten Through Grade Twelve**

Grade level	*Science processes*	*Descriptions of content*	*Principles/Examples*
K-3	1. Observing 2. Communicating 3. Comparing 4. Ordering 5. Categorizing	Focuses on one-word descriptions, discreet ideas	**Static-organizational principles** • Sea water is salty. Water in most lakes and rivers is not salty (definition by class). • Flowers produce seeds that grow into new plants (definition by function). • Machines are devices that make some tasks easier (definition by function).
3-6	1-5 above, plus 6. Relating	Focuses on principles, generalizations, laws	**Active-relational, interactive principles** • A force is a push or pull (relational). • Poikilothermic (cold-blooded) animals have body temperatures that vary with surrounding temperatures (relational).

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Exhibit 6, pg. 2 Examples of Content and Student Skills

Science: Ohio's Model Competency-Based Program (p. 48)

Grade Level	Scientific Inquiry	Scientific Knowledge	Conditions for Learning Science	Application for Science Learning
	The learner will:	The learner will:	The learner will be:	The learner will be:
Grade 7	... predict what might be wrong with an experimental design when observations vary widely, and propose and execute design changes to correct these problems. ... analyze a variety of divergent explanations for similar natural phenomena. ... store, retrieve and manipulate information with a computer, using various files types (e.g., topical, alphabetical numerical, key-word files) and use simple files of their own design. ... utilize mathematical models (e.g., number lines, graphs, and charts) for exploring, organizing and displaying information and identifying trends and patterns. ... utilize analogies to understand how things work. ... make and accurately record observations, inferences, hypotheses, experiences, ideas, and explanations. ... find and read facts and figures in news media, books, or databases, make sense of them, and construct appropriate lists, tables, or graphs.	... investigate principles which describe the impacts of various forms of mechanical and electromagnetic waves on various organisms and objects. ... investigate patterns in nature (e.g., vibrations, probabilities, behaviors, growth, migrations, energy transmission and transformation). ... investigate resistance to change in natural and technological systems (e.g., dynamic equilibrium, inertia, electrical resistance). ... investigate the interactions of objects and organisms in simple technological and natural systems. ... investigate qualitatively the geometry and regularity of motion found in interactions in the solar system (e.g., planetary motion, comets, satellites). ... investigate the organization within and among the atmosphere, hydrosphere, lithosphere and celestial sphere. ... investigate the properties of new materials as compared with those of the familiar materials.	... using a diversity of writing styles to communicate scientific ideas. ... using primary sources and interviews to examine the history of science concepts. ... seeking explanations for conflicting descriptions of the same event. ... observing and discussing the process of community decision making. ... investigating living and nonliving things holistically and by component structures and functions through (e.g., models, simulations, multimedia, technologies, evidence collection). ... using multimedia and human contacts to investigate how different cultural factors exert influences on scientific perceptions around the world. ... maintaining records of group investigations (e.g., accounts of processes, results, individual contributions). ... visiting community workplaces to examine applications and reinforce understanding of scientific concepts.	... writing and following instructions (e.g., algorithms, formulas, flow diagrams, and sketches). ... designing, building, and testing working models of structures and systems. ... differentiating between the scientific and non-scientific information found in folklore. ... choosing everyday consumer products that utilize recent innovations (e.g., polymers, silicon chips, computer software). ... making decisions in light of possible outcomes of different genetic combinations of inherited characteristics. ... choosing, modifying, and inventing tools, instruments, devices, computer-based technologies and procedures that enable student developed investigations to proceed more efficiently. ... analyzing advertisements and technical information to recognize biases and misrepresentation of scientific information.

Exhibit 7 Examples of Standards into Practice

Massachusetts Curriculum Framework for Mathematics, (p.49)

	Traditional Paradigm	*New Paradigm*
Problem Solving	Problem solving means solving word problems. Problems are, in fact, computational exercises embedded in a simple context. They are done following introduction and practice of a specific procedure to reinforce the procedure and to provide examples of where the procedure is used. There is an assumption that complex problems are OK for "advanced" students, but too difficult for "slower" students, only few *students* are expected to attempt the more complex problems.	*Problem-solving is the focus of mathematics programs. All students are capable of solving problems, but need many opportunities to solve problems. Students need to develop and use a variety of strategies in solving problems, and understand the use of multiple strategies to solve the same problem. They must feel that there are multiple solutions to problems, or multiple pathways to solutions.*
Communication	The primary means of communicating *mathematics* is one-way: from the teacher (or text book) to the students. Students are expected to communicate their knowledge of *mathematics* by using taught procedures in response to questions on tests. Students are expected to memorize mathematical definitions.	*Students learn when they reflect on ideas and communicate their thoughts with others. In mathematics classes, students frequently interact with other students to solve problems and to sharing their strategies and seeking solutions to problems. Students frequently explain and justify their thinking in writing. They come to understand mathematical terms by comparing and contrasting examples with other students before a formal definition is presented.*

Mathematics Framework for California Public Schools, K-12, (p.58)

	Traditional practices	**Some alternative practices**	**Recommended practices**
Computational ▶ Procedures	Procedures are given focus. Emphasis is placed on learning the steps to perform an algorithm and on providing enough practice so that the procedure becomes automatic for students.	Procedures are given major focus. Manipulatives are used to teach and explain the algorithm although students are still expected to become proficient performing the algorithm with paper and pencil so that they can do well on tests that require quick and accurate computation.	Students develop a range of computational procedures, with a greater emphasis on number sense than on algorithms. They invent and use a number of different computational procedures to assist them in solving problems. Students are expected to decide the most efficient means to calculate an answer for a given situation—without assistance or with the aid of a calculator or paper and pencil.

- multiple assessment strategies
- interdisciplinary connections
- discourse, dialogue, and argument
- flexible uses of time and facilities
- a mix of learning tools
- experiments, problem solving, and alternative solutions
- representing ideas through writing, graphing, and mapping

We began our review of the pedagogy within frameworks by first categorizing the pedagogical strategies and then documenting how extensively the frameworks discussed pedagogical techniques. We distinguished three ways the frameworks presented pedagogy: (1) as lists or outlines with little detail about application; (2) as examples or vignettes that explained or modeled new practices; or (3) contextualized throughout the framework, modeling how to apply new instructional practices.

Table 8 summarizes how states addressed pedagogy in the frameworks since 1990, and how they are presented: lists (L) of suggested activities/tasks with the pedagogical approach (e.g., active lessons); examples (E) or vignettes that give more detailed illustration of the pedagogical approach in a classroom; or contextualized (C) use of examples, vignettes, and activities throughout the framework both to demonstrate content and discuss curriculum design and classroom implementation.

Twenty frameworks presented pedagogical principles through lists or outlines and, occasionally, illustrated sample problems, processes, or strategies to convey how a content area might be taught. Florida and Arizona science frameworks are examples of this type of presentation (see Exhibit 8 for examples from these frameworks).

Eight states in the set of 40 recent frameworks included little or no attention to pedagogical issues, focusing instead on content goals or standards. Eight other states delved deeply into pedagogical issues, reflecting a vision of pedagogical change consistent with the content changes their frameworks propose. These frameworks were designed to do more than guide policy and establish content standards. The eight pedagogically extensive documents illustrated the concepts through discussions of practices that connect new content with a range of active learning activities. They "contextualized" pedagogy and explored teaching and learning elaborately.

Among all the frameworks, those in mathematics and those that combined mathematics and science dealt in greater detail with pedagogical practices. The existing consensus from the NCTM *Standards* on preferred mathematics teaching meant that mathematics frameworks authors had ready pedagogical guidance. This consensus was rapidly building in science in 1994. As the science community completes and distributes its agreed on content standards, the resources for describing how to teach the content standards will also be more accessible to frameworks authors and practitioners.

TABLE 8

Teaching Practices Addressed by Frameworks

(N = 40 frameworks since 1990[1])

Mathematics Frameworks

TEACHING PRACTICES	STATES															
	AR	CA	ID	IN	KS	MA	MN	MS	NJ	NV	NC	SC	TN	TX	UT	WV
Constructive/active lessons	L	C	E	C	E	C	L		E			C	L			L
Technological applications	L	C	E	C	L	C	C		L	L	L	C	L	L		L
Assessment strategies	L	C	E	C	E	C	L		E			E				
Interdisciplinary connections	E	C	E	C	E	C	L		E			C		L		L
Discourse and dialogue	L	C				C			E			C				
Flexible uses of time and space		C				E			L			E		L		
Using tools and technology	C	C	E	C	E	C	L		E	L		C		L		L
Experiments		C	E		E	C	L		E			C				L
Writing and graphing		C	E	C	E	C	L		E			C		L		L

Science Frameworks

TEACHING PRACTICES	STATES															
	CA	CT	FL	IA	IN	KS	LA	MA	MI	MN	MS	MT	NC	NV	OH	UT[2]
Constructive/active lessons	C	L	E	E	L	L	L	C	E	L	L	L			L	
Technological applications	E	E	E			L		C	E	L				C	L	
Assessment strategies	E	L	E	C	L		L	C		L					L	
Interdisciplinary connections	E	L	E	L		L		C	E	L		L		L	L	L
Discourse and dialogue	C	C	E	E		L		C							L	
Flexible uses of time and space	E	E	E					E							L	
Using tools and technology	E	L	E		L	L		C	E	L		L			E	L
Experiments	E	L	C		L	L	L	C	E	L	L				E	L
Writing and graphing	C	L	E				L	C	L	L		L			L	L

Combined Frameworks

TEACHING PRACTICES	STATES							
	CO	DC	KY	ND	NE	NM	NY	OK
Constructive/active lessons		L	C	L	C		E	L
Technological applications		L	C	L	E		C	L
Assessment strategies		L	C				C	L
Interdisciplinary connections		L	C	L	C		C	L
Discourse and dialogue		L	C		C		E	L
Flexible uses of time and space		L	C		C			
Using tools and technology		L	C	L	C		C	L
Experiments		L	C	L	C		E	
Writing and graphing		L	C	L	C		E	

Note:

C = **Contextualized Examples/Vignettes:** In many places throughout the framework, pedagogy is demonstrated through examples or vignettes that illustrate teaching practices in relation to specific content and classroom situations.

E = **Examples/Models:** "How-to" demonstrations or illustrations of teaching practices.

L = **Lists/Outlines:** Lists or outlines of activities or teaching practices with little or no detail about how practice is to be used within classrooms or by teachers.

Source: Council of Chief State School Officers, Study of State Curriculum Frameworks in Mathematics and Science, 1995.

Exhibit 8 Examples of Classroom Practices

Science for All Students: The Florida PreK-12 Science Curriculum Framework (p. 37)

Comparison of Traditional and Recommended Practices in Science Instruction

TABLE 1

TRADITIONAL	RECOMMENDED
Science for some	Science for all
Behaviorist Based	Constructivist Based
Behavioral objectives - learning is based on measurable behaviors	Conceptual objectives - learning is based on constructing meaningful concepts/learning
Text based	Hands-on/Minds-on
Passive	Active
Confirmatory investigation	Problem solving investigation
Fact oriented	Concept oriented
Teacher demonstrations	Labs/Field experiences
Science is seen as a single subject with little relationship to mathematics, social studies, language arts, art, or music.	Science is seen as part of an interdisciplinary world, emphasis is on relating science to the students' world, which is not compartmentalized.
The teacher imparts knowledge and students learn it; communication is generally one way.	The teacher is a facilitator of learning and a learer as well; students are learners and teachers in some situations; networks emerge instead of one-way forms of communication.
Limited use of technology.	Full integration of appropriate technology in instruction.
Exclusive use of whole group instruction.	The teacher imparts knowledge and students learn it; communication is generally one way.
Competive learning	Cooperative learning
Exclusive use of paper and pencil assessment; assessment	Multidimensional assessment; assessment integrated with instruction.
Many science topics covered with little depth.	Few science topics covered with more depth.
Single exposure.	Spiral curriculum.

Arizona Science Essential Skills (p. 22)

MIDDLE GRADES

Goal 3: Science Content

To acquire and apply appropriate scientific knowledge to interpret the natural world.

Student Outcomes	Examples of Indicators
Organization—Recognizes and explains that ideas and descriptions about natural phenomena can be organized in different ways	• analyzes an ecosystem in terms of its populations and communities • describes organizational patterns of matter such as atoms to molecules, crystals, etc. • identifies organizational patterns in space, such as earth-solar system • identifies organization levels of technologies such as communication, agriculture, biotechnology, transportation, space and computer technology • describes component parts of natural and technological systems
Cause and Effect---Searches for and identifies valid cause and effect relationships in the natural world	• identifies the effects of poor nutrition on health • describes natural phenomena in terms of cause and effect (e.g., weather, erosion) • creates experiments that deal with the reactions of a variety of living things under different environmental conditions • discovers concepts of the physical world through experimenting with cause-and-effect relationships with physical phenomena • designs an invention to produce a desired effect

Of the pedagogical strategies we sampled, we found the most often recommended were constructive and active lessons; technological applications; using tools, technology, and experiments; and writing and graphing. Classroom assessment and interdisciplinary connections were discussed somewhat less frequently. Nine frameworks referenced all nine pedagogy categories outlined in the concept map. "Discourse and dialogue" and "flexible uses of time" were the two categories least developed by frameworks authors. Some examples of the varied presentations of pedagogy follow.

Four Examples of Pedagogy Guidance

Nebraska embeds pedagogical principles and goals in its "measurable performances." In elementary measurement, for example, the framework establishes these expectations for what students will know how to do with their advancing knowledge of measurement (Nebraska, 1994, p. B-3):

- Explore, identify, and use appropriate measurement tools.
- Estimate, construct, and justify the solutions to problems using appropriate units of measure.
- Solve problems taken from actual situations that relate measurement concepts to other disciplines.

The Nebraska framework explores how to teach towards these goals in its follow-up discussion, explaining that a central learning strategy involves students in selecting appropriate units of measurement. Encouraging students to develop their own measurement procedures and formulas is one way to do this.

Nebraska sets out "measurable performances" for each concept of science it includes, and explains the interaction of teaching and content through a discussion it calls "A Closer Look." The content sections incorporate several brief, but practical, "sample investigations" that teachers can use to help students construct their own understanding of scientific principles by devising categories and building their own arguments for how or why concepts work. Nebraska incorporates several teaching principles—constructive lessons, interdisciplinary connections, discussion, using tools and technology, experiments, and writing and graphing—within these sample investigations (see Nebraska examples in Exhibits 4 and 5).

California's frameworks in both mathematics and science include extended discussions about ways to unify important ideas into a few core themes. In middle-grade mathematics, for example, mathematical content can be organized around three unifying ideas: proportional relationships, multiple representations, and patterns and generalizations. These themes, the framework explains, can be a bridge between elementary and high school mathematics. The framework demonstrates how basic middle and high school subjects can be taught both as separate content areas and in terms of their commonality, through "units." Units of study offer students repeated experiences coordinating and applying a range of mathematical content, while emphasizing the common themes among content areas. California Mathematics models the use of a mathematics unit that uses data collection and analysis to develop students' capacity to reason mathematically. It also capitalizes on personal interests and communication facilities, showing how teachers can incorporate into their teaching a genuine respect for the diversity of students' language and needs (see California example in Exhibits 9 and 4).

To strengthen the linkage across the *Massachusetts Mathematics and Science and Technology Frameworks*, each volume includes chapters on pedagogical principles that follow similar outlines.

Massachusetts builds its pedagogy on a Haitian Creole idea, *cheche konnen*, which means a search for knowledge. This idea has also become the basis of a developmental science program for elementary-age children:

> In Cheche Konnen what students think is at the center of their activity. They explore their own questions, design studies, collect, analyze and interpret data, build and argue theories, and evaluate evidence. Investigations are interdisciplinary; science, mathematics and language (talk, reading and writing) are linked, and recognized as essential tools of scientific inquiry (*Massachusetts Curriculum Frameworks for Science & Technology*, p. 25).

Massachusetts is an example of a state that uses an array of diagrams to link content and pedagogy. First, it outlines the content core for each grade cluster in terms of four broad themes that embed pedagogical ideas within them: science as inquiry, science subject matter, technological design, and science and human affairs (see Massachusetts example in Exhibit 4). Next, each broad theme is diagramed with its pedagogical connections. Later, the interrelationships among the content and learning components in science and technology are depicted with a diagram.

The Kentucky framework offers teachers a highly readable and practical notebook of pedagogical strategies, each connected directly with a content standard, but without lengthy discussion. For each mathematics and science "learner outcome" there are two pages of teaching-focused activities that suggest "learning links" and "related concepts" for presenting the outcome. Using a compact layout, the framework lists several "demonstrators"— concrete tasks—that can be used by students both to learn and to demonstrate their knowledge of an outcome. For each outcome, the framework also provides teaching and assessment strategies, ideas for incorporating community resources into instruction, and applications across the curriculum (see an example from the Kentucky framework in Exhibit 10, as well as other examples in previous exhibits). In an endnote, called "Reflections," the framework conducts a dialogue with the teacher regarding ideas for teaching the outcome. For the learner outcome on studying scientific systems, subsystems, and components and their interactions, this is part of the "Reflections" section:

> "What is it made of?" "How does it work?" Investigating answers to these questions leads students to an understanding of the interconnectedness of all things. No single object, organism, or idea exists without influencing or being influenced by something else. For this reason, the study of systems and interactions is important for students. They can begin to analyze the pieces and parts of things and how they work together, whether they are working with systems in the human body, parts of a machine, or the ideas of an argument (*Kentucky Curriculum Framework*, Vol. I, p. 63).

Finally, mathematics and science educators have used vignettes to model, through text, a new vision of classroom practice. Vignettes are used relatively sparingly in these frameworks, however (see Appendix F for sample vignettes). Their richness makes them a complex strategy for getting across an idea, so they are most useful when they can be carefully read and discussed by colleagues who expect to use them as a model for their own work. When vignettes are well done, they can portray a new vision of teaching and learning that exhibits reflective teaching. Their complexity means that they do not lend themselves to quick reading, and they can lengthen frameworks documents, making them less suitable to a broad-based audience that includes those outside the education community.

Exhibit 9 Example of an Instructional Unit

Mathematics Framework for California Public Schools (p. 36)

likely to use common sense inside. Working with mathematics to communicate helps all students—whether they are fluent in English or another language or are developing proficiency—benefit from dealing with the precision of speech and writing that good mathematics demands. Experience from language arts and research in cooperative learning and writing in mathematics introduce more issues. Many writing specialists believe that a command of diction, sentence structure, and grammar develops better when students write for a purpose and an audience rather than work on isolated exercises. The same approach is valid in mathematics as well. Children cannot learn to communicate in isolation because when they communicate, they communicate with others. That communication is most effective when students express themselves mathematically for a clear purpose and audience.

A working example of meaning, purpose, and audience

The teacher assigns each student to choose something wanted (e.g., a bicycle, a tape deck, a trip to Latin America) but cannot afford. Work begins with research—trips to stores, to agencies, catalog shopping, and so forth—to collect data. How much do these things cost? Is there much variation from store to store? From vendor to vendor? Are there options or variations in quality that affect the price? After the research is completed, students give a written report or oral presentation to their group. The teacher helps students explore the mathematical elements of their choices and decision.

Next, students develop a plan for saving the money to get what they have reported on. They brainstorm savings schemes, from piggy banks to interest-bearing accounts, and money-making ideas, from lemonade sales to summer jobs. The students now have a reason to assimilate the mathematical concepts they need to evaluate the relationships between cost, savings, and time required. The concepts become part of the students' natural thinking; they construct durable knowledge that corresponds with what they already know. They use the mathematics, intertwined with common sense and experience, to complete a report. The report is a proposal to someone to lend them the money; their savings scheme serves as the plan for how they will pay the money back.

The students produce a proposal for a committee of students or an outside guest, whom they attempt to persuade through the strength of mathematical reasoning. In preparation the teacher leads students to use a range of mathematical representations—words, tables, diagrams, and formulae—in a specific context. Other students respond to drafts of the report and to the presentation. Students revise and edit their reports. By the time the final report is produced, everyone has focused on issues of what defines quality and insight in mathematical work.

Transformations: Kentucky's Curriculum Framework (p. 63)

Core Concept: Systems and Interactions

Sample Elementary Activities

- Using a variety of objects, design and construct a machine which can be used to elevate a box of books from the floor to a table. PE, P
- Identify subsystems in a habitat (e.g., pond, forest, aquarium) and investigate their interactions. PE, OE, P
- Complete an electrical circuit, identify its components, and describe evidence of their interactions. PE, OE, P
- Investigate the relationship among physical activity, breathing, and pulse rate. Use computer software to generate a 3-variable graph. PE, P
- Choreograph the movement and revolution of the earth to demonstrate the reasons why seasons change. PE, P

Applications Across the Curriculum

Variations on a theme: The Aquarium

Language Arts
- Build a class aquarium and keep a journal with daily observations. Describe evidence of interactions of subsystems within the aquarium. P

Mathematics
- Develop strategies to determine the amount of water in an aquarium. Consider the rocks, plants, and other matter in the aquarium. OE

Social Studies
- Design a flowchart illustrating a production/consumption chain for the class aquarium. PE, OE

Arts and Humanities
- Listen to the song "I Know an Old Lady Who Swallowed a Fly." Rewrite to illustrate the interacting subsystems in the class aquarium. P
- Design and conduct an investigation to measure the effect of color, shape, and texture on fish behavior in the aquarium. PE, OE, P

Practical Living
- Develop a chart illustrating costs of purchasing and maintaining various aquaria. PE, OE

Vocational Education
- Invent a tool to help clean the aquarium more effectively or quickly. P

Reflections

"What is it made of?" "How does it work?" Investigating answers to these questions leads students to an understanding of the interconnectedness of all things. No single object, organism, or idea exists without influencing or being influenced by something else. For this reason, the study of systems and interactions is important for students. They can begin to analyze the pieces and parts of things and how they work together, whether they are working with systems in the human body, parts of a machine, or the ideas of an argument.

In The Fifth Discipline, Peter Senge discusses his concept of systemic thinking in which no one thing stands alone. Every single thing is connected in overt and covert ways to many other things. Through the study of systems and interactions, students can begin to understand that each object or person has an influence—large or small, intentional or unintentional—on the entire system. With encouragement, students will learn to extend this search to understand the ways their entire world is connected.

Source: Senge — The Fifth Discipline, The Arts and Practice of Learning Organizations

Equity in the Curriculum

In the study design, the advisory panel identified the area of equity and inclusiveness of the mathematics and science curriculum to be a key element in analyzing frameworks. A critical question was the extent to which equity is a focus of frameworks and how frameworks try to ensure inclusiveness in mathematics and science teaching and greater success of diverse students in these subjects. Mathematics and science reform based on standards has a central proposition that all students can learn and do high-level mathematics and science. U.S. schools offer mathematics and science instruction to all students, but a only a minority of students achieve at high levels. Students from specific types of backgrounds, such as racial/ethnic minorities, females, and lower socioeconomic backgrounds, have had less participation and success in mathematics and science. A major challenge for implementing national standards in mathematics and science will be in delivering high-quality, demanding content to all students.

Frameworks need strategies to address equity in mathematics and science.

The secondary mathematics and science curriculum in public schools has traditionally been differentiated: High-achieving, college-bound students took more science and mathematics courses and more advanced courses than did lower-achieving, non-college-bound students. National professional standards and reports recommend that all students be taught mathematics and science that reflects high content and skill standards. In developing frameworks, states need to address the question being asked by educators of how to design and deliver curricula that can move all students into academically challenging mathematics and science in elementary school and on into middle and high school.

The main equity issue in mathematics and science curriculum, largely not addressed in state frameworks, is the substantial differences in the content that is actually taught to all students, and how the curriculum differs by the race/ethnicity or gender of students. The review teams found that recent frameworks all include a statement on the need for greater equity in mathematics and science education in the rationale or vision section, but a consistent weakness of frameworks is the lack of presentation of strategies and practices that promote equity. Equity needs to be woven through the frameworks in a self-conscious way. The reviews revealed that some frameworks start out giving some attention to equity issues, but let the issue drop further on in the document.

The conceptual mapping identified sections in the frameworks that explained how states planned to implement an equity agenda in mathematics and science education, and it recorded whether frameworks made their commitments explicit in 10 areas: vision, vignettes, instructional strategies, materials selection, assessment approaches, staff development, teacher preparation, hiring practices, community involvement, and policies. We reviewed each framework a second time with a focus on equity to specify how the states addressed the equity issues they typically raised in the vision statements. For example, if sample assessment exercises are included, do they model use of multiracial or multicultural examples, such as scenarios for word problems? If instructional strategies are suggested, do they identify various classroom practices, including options that may be effective with students with little success in mathematics or science? If methods of redesigning curriculum are presented, are problems and possible solutions related to tracking and differentiated course levels discussed?

The concept mapping showed that frameworks give broad goals related to equity but little attention to how to address inequity in curriculum implementation:

- 10 of 20 frameworks completed before 1990 discuss equity in the vision or rationale statement—10 do not address equity at all.
- 3 of 20 older frameworks provide one or more strategies or practices for improving equity in the curriculum.
- 33 of 40 frameworks completed since 1990 discuss equity in the vision or rationale.
- 20 of 40 newer frameworks provide one or more strategies or practices addressing equity.

Thus, frameworks completed since 1990 typically do state the need to improve equity and access of learning opportunities in mathematics and science through their vision statements and, in some cases, in other sections of the frameworks. But only one-half of the recent frameworks have one or more practical idea or example for including equity in the curriculum through use of vignettes, models, assessment approaches, professional development, or other specific strategies.

Table 9 shows results of the mapping of equity strategies or practices. The results show that nine of 40 frameworks addressed equity through vignettes, and 13 addressed equity in instructional strategies or examples (or, half of the 40 analyzed, in total). The conceptual-mapping process identified equity strategies or practices in curriculum implementation or pedagogy by checking if frameworks (a) used examples with multicultural, cross-gender, or diverse student groups, (b) specifically addressed needs of students from varied backgrounds or cultures related to instruction, or (c) addressed curriculum organization, grouping, or tracking as they affect diverse groups of students.

Frameworks can address equity issues in strategies for student assessment, such as by minimizing bias or by providing alternative opportunities for demonstrating knowledge or through examples of assessment exercises that demonstrate equity. Among the 40 frameworks since 1990, only 11 discussed or modeled student assessment that incorporated equity issues.

Eight of the 40 recent frameworks described specific policies or policy recommendations for promoting equity and inclusiveness in curriculum or instruction or assessment, and nine of the frameworks had specific guidelines for selecting curriculum materials or textbooks that supported high standards for diverse groups of students.

The content analysis shows that equity is a more important element of framework development in recent frameworks, as compared to the complete set of frameworks. The trend appears to be toward greater attention in frameworks on building in strategies and suggestions for how high levels of mathematics and science can involve all student populations.

Equity strategies would aid curriculum implementation.

A clear statement on the groups that are more likely to be affected and the harmful effects of curriculum tracking would be a useful addition to state frameworks. Frameworks should provide concrete strategies for improving access, representation, and performance of minority students and women in mathematics and science at all grade levels. **Frameworks could be helpful in suggesting instructional approaches and activities aimed at reaching students with less success in mathematics and science.** The following are frameworks with some examples of equity strategies: New Jersey mathematics standards set guidelines for race/ethnic and gender representation in all mathematics classes; Ohio mathematics and science, Michigan science, and Massachusetts mathematics and science frameworks have

TABLE 9

Framework Methods of Addressing Equity in Curriculum

(N = 40 frameworks since 1990[1])

Mathematics Frameworks

EQUITY ADDRESSED IN	STATES																TOTAL
	AR	CA	ID	IN	KS	MA	MN	MS	NJ	NV	NC	SC	TN	TX	UT	WV	16
Vision/rationale	◆	◆	◆	◆	◆	◆	◆	◆	◆		◆	◆	◆	◆		◆	11
Vignettes		◆		◆		◆			◆								4
Instructional strategies	◆	◆				◆	◆		◆								5
Materials selection		◆				◆											2
Assessment approaches	◆	◆	◆			◆						◆		◆			5
Staff development						◆	◆										2
Teacher preparation						◆											1
Hiring practices																	0
Community involvement		◆				◆											2
Policies and recommendations		◆	◆			◆	◆										4

Science Frameworks

EQUITY ADDRESSED IN	STATES																TOTAL
	CA	CT	FL	IA	IN	KS	LA	MA	MI	MS	MN	MT	NV	NC	OH	UT[2]	16
Vision/rationale	◆	◆	◆	◆	◆	◆		◆	◆		◆		◆		◆	◆	8
Vignettes			◆			◆		◆			◆						3
Instructional strategies	◆	◆	◆					◆	◆		◆						5
Materials selection	◆	◆						◆	◆			◆					4
Assessment approaches			◆					◆									2
Staff development								◆									1
Teacher preparation								◆									1
Hiring practices																	0
Community involvement			◆					◆									2
Policies and recommendations			◆					◆									2

Combined Frameworks

EQUITY ADDRESSED IN	STATES								TOTAL
	CO	DC	KY	ND	NE	NM	NY	OK	8
Vision/rationale	◆	◆	◆	◆	◆	◆	◆	◆	8
Vignettes			◆						1
Instructional strategies		◆	◆				◆		3
Materials selection			◆						1
Assessment approaches		◆	◆				◆		3
Staff development			◆						1
Teacher preparation									0
Hiring practices									0
Community involvement		◆	◆						2
Policies and recommendations		◆					◆		2

Source: Council of Chief State School Officers, Study of State Curriculum Frameworks in Mathematics and Science, Draft, 1995.

examples that use multicultural references; California mathematics gives recommendations on reducing excessive tracking and grouping (see Exhibits 11 and 12 for examples).

Frameworks have been relatively silent on equity issues in mathematics and science for several reasons. Some states have focused on defining or outlining mathematics or science content, not implementing content or designing curriculum. Some states have addressed general issues in curriculum design and implementation, but have stayed away from school and curriculum organization decisions. Some states have found it difficult to address equity issues.

But this silence will not last long. National standards and national professional organizations, such as AAAS and NSTA, are pushing issues of content, implementation, curriculum organization, and equity together—by statements concerning knowledge and skills needed by all students for science and mathematics literacy and by recommending approaches to scope and sequence (NSTA), K-12 benchmarks and curriculum modeling (AAAS), and "program standards" and "system standards" (NRC, draft).

Educators are seeking assistance with a number of questions on how these recommendations and ideas will be accomplished:

- How do we ensure that content standards will be applied to all schools and students?
- How do we bring staff to understand that all students can reach high levels of mathematics and science?
- What knowledge and skills do teachers need to teach to content standards for all students?
- What instructional approaches need to be developed?
- How can curriculum organization begin to be reconceptualized at school and district levels?
- How do we structure curriculum decision making so that educators in schools are part of the professional decisions on how curriculum is designed and delivered, not simply recipients of decisions?

Not all states may design their curriculum frameworks as a resource for addressing these questions or assisting educators in considering how to address them. States may designate other documents and resources for working with educators on these questions. Assuming a standards-based approach to mathematics and science education, the state framework is likely to need to refer to these issues and be linked to the strategies states choose for addressing equity and curriculum implementation issues.

Mathematics Framework for California Public School, K-12, (p. 46)

Steps That Can Be Taken

What can be done to take advantage of what diversity offers? Some suggestions in several categories are as follows:

1. *Curriculum and assessment.* Use contexts and representations from other cultures. Provide opportunities for presentations in other languages and activities that require materials familiar to special groups. Many students can, for instance, demonstrate mathematical concepts through their skill in using money.
2. *Staff development.* Arrange for opportunities for teachers to expand their understanding of student differences and other cultures through in-service training and sharing.
3. *Quantity and quality of instructional time.* Make sure that not only equal time but equal quality as well are given to all students. Arrange for peer observations or videotaping for self-checking.
4. *Grouping.* Maximize time spent by students in heterogeneous groups. Minimize time spent in tracked or special-ability groups.
5. *Beyond the bells.* Pay heed to the time students spend outside school. Arrange times and places for study groups to do homework. Have students exchange phone numbers so that the students can discuss homework problems. Involve the community (parents, business, local colleges) in organizing supportive settings for students to study, work on projects, or do homework. Provide programs such as "Family Math," in which students and their parents understand and enjoy mathematics together in the same way in which they might enjoy reading together.
6. *Community and parents.* Call on the many resources available from members of the community and parents, such as translation or language interpretation, career information, and assistance provided by mentors.
7. *Systematic support.* Meet with all groups involved, including students, and plan systematic support. Evaluate, revise, and update the plan regularly.

A large part of the mission will be giving up the norm: how students are viewed, what they are to be offered, and what gains are expected of them. The issues are complex, involving the social context of the classroom, the general culture and languages, culture and languages specific to mathematics, influences outside school, and the need for teacher to have opportunities to learn more. The new norm will be achievement in mathematics for all students.

New Jersey Mathematics Standards, (p. 15)

1. All students will be afforded full opportunity for mathematical learning and will be expected to demonstrate high levels of mathematical thought.

Experiences will be such that all students:

- A learn mathematics in classes which reflect the diversity of the total school student population;
- B are challenged by rich, open-ended problems to which they can respond at a variety of levels;
- C receive equitable treatment without regard to gender, ethnicity, or predetermined expectations for success;
- D have the opportunity to study a common core curriculum containing challenging ideas and tasks rather than one that dwells on repetitive and low-level cognitive activities;
- E avail themselves of services that help them understand the mathematical skills and concepts necessary to assure success in the core mathematics program;
- F frequently interact with parents and other members of their communities, both men and women from a variety of cultural backgrounds, who use mathematics in their daily lives and occupations;
- G learn mathematics by working with well prepared mathematics faculty whose composition and assignments reflect the gender and ethnic diversity of New Jersey;
- H see mathematics as integral to the development of all cultures and civilizations actively experience a full program of meaningful mathematics so that they can pursue post-secondary education.

Chapter 4: Frameworks and Mathematics and Science Reform

A central theme of systemic education reform is that state policies are coherent and consistent in moving education toward high standards for student learning. State frameworks have policy implications: They represent a set of recommendations about subject content, or, in some states, a policy mandate for the content of curriculum. In the past, frameworks focused on outlining curriculum content, with relatively little treatment of pedagogy, resources, and other factors that affect the implementation of content. More states are currently viewing the curriculum framework as an important, and sometimes central, link in a systemic approach to reform of mathematics and science. Many frameworks show the important relationship of content to instructional practices in classrooms, as well as school, district, and state policies that affect the implementation of challenging mathematics and science content for all students. In some states, educators view the framework as an important source document for a state's approach to reform in mathematics or science.

In this chapter, we examine two aspects of the role of frameworks in mathematics or science reform. First, the conceptual-mapping process identified how subject content in each framework is explicitly linked to policies on student assessment, teacher education, professional development, selection of texts and materials, facilities, and other "enabling conditions" for high-quality mathematics and science education. Results of the qualitative reviews produced several issues about the policy linkages.

Second, CCSSO interviews with state mathematics and science supervisors identified how frameworks are being disseminated to educators in the state and how the new frameworks are being used in staff development.

Policy Linkages: Professional Development, Assessment, Teacher Education, Materials and Resources

The content analysis examined the extent to which frameworks refer to nine areas of state education policy and describe the current or recommended relationship of these areas to subject content in the framework:

- Professional development
- State assessment
- Materials and texts
- Teacher preparation and certification
- Support services
- Technology integration
- School governance
- Facilities
- Community involvement

The content-analysis approach to policy linkages had limitations. Some frameworks did not indicate links from subject content to other state policies, even though these links may have been provided

through other documents or processes. The CCSSO study did not have resources to fully research the extent to which frameworks are linked to state policies, such as through on-site interviews or in-depth review of state documents. This study's findings provide a summary of the extent to which the framework itself describes linkages to state policies.

Our analysis of policy linkages in all 60 frameworks showed the following:

- Only 3 of 20 mathematics and science frameworks *completed before 1990* have one or more policy linkages, and these 3 frameworks recommend policies.

- 14 of 40 frameworks completed *since 1990* (or one-third) report on existing policy linkages, and 20 frameworks (one-half) give recommendations of policy linkages. A total of 17 (of 40) recent frameworks have no policy linkages.

The overall concept-mapping findings on policy linkages show a trend toward greater attention to state assessments, professional development, and other policies in recent frameworks. Considering the strong statements about education reform in the vision and rationale for the frameworks, however, we might expect to see many more frameworks outlining the implications of change in mathematics and science content for state policies.

Frameworks from SSI states and Eisenhower framework projects tend to have more policy linkages than do other frameworks. These national initiatives emphasize the relationship between curriculum frameworks and state policies on student assessment, professional development of teachers, teacher education, and materials.

Table 10 shows a more detailed analysis of linkages in frameworks completed since 1990. The table shows which state frameworks *recommend* (R) that mathematics and science content statements be linked to other state policies and which frameworks *report existing linkages* (L). Nine categories of policy linkages are reported individually for the 40 frameworks completed since 1990. The policy linkages that were analyzed include "enabling conditions" for high-quality mathematics and science education, which were initially identified by the study's advisory panel. Across the nine policy areas analyzed, an average of two linkages were identified per framework, with a high of seven types of linkages in the Massachusetts frameworks, to six in South Carolina mathematics, to no linkages in several frameworks.

One-half of frameworks link content to state assessments.

Twenty-one of 40 recent frameworks address state student assessment programs in the framework, with only 10 reporting an existing linkage between the framework and state assessments and 11 providing recommendations on improvements in state assessments. More states are now using frameworks as a basis for moving toward change in the nature of state student assessment programs.

State frameworks often recommend that classroom assessment be designed for consistency with content standards, but the review teams found only a few frameworks that provide models or examples of assessment exercises that exemplify standards. State frameworks can outline principles that educators want reflected in student assessments to make them consistent with desired content and instruction. Recent frameworks generally recommend alternative assessment strategies for classrooms that are consistent with

TABLE 10

Linkages of Mathematics/Science Content with State Policies, as Described in Frameworks

(N = 40 frameworks since 1990[1])

Mathematics Frameworks

POLICY	STATES															TOTAL	
	AR	CA	ID	IN	KS	MA	MN	MS	NJ	NV	NC	SC	TN	TX	UT	WV	Rptd	Rcmnd
Professional development	◆	✓	◆			◆	◆		◆			◆	◆	✓				
State assessment	✓	◆	✓	✓	✓	◆	◆		◆			◆		✓				
Materials and texts		✓				◆						◆		✓				
Teacher preparation						◆			◆			◆						
Student support services																		
School governance						◆			◆									
Technology integration			◆			◆	◆		✓			◆	◆	◆				
Facilities																		
Community involvement						◆						◆						

Science Frameworks

POLICY	STATES															TOTAL	
	CA	CT	FL	IA	IN	KS	LA	MA	MI	MS	MN	MT	NV	NC	OH	UT	Rptd	Rcmnd
Professional development	✓	✓	◆					✓	◆			◆						
State assessment	◆	✓	◆					◆			✓				✓	✓		
Materials and texts	✓	◆						◆			◆	◆			◆			
Teacher preparation								◆				◆						
Student support services		✓													◆			
School governance								◆			◆							
Technology integration		◆						◆	◆						◆			
Facilities	◆	◆	◆									◆			◆			
Community involvement			◆					◆				◆						

Combined Frameworks

POLICY	STATES								TOTAL	
	CO	DC	KY	ND	NE	NM	NY	OK	Rptd	Rcmnd
Professional development		◆	✓				◆			
State assessment	✓	◆	✓				◆	✓		
Materials and texts		◆	✓							
Teacher preparation		◆	✓							
Student support services			✓							
School governance			✓				◆			
Technology integration		◆	✓					✓		
Facilities			✓							
Community involvement		◆	✓							

Source: Council of Chief State School Officers, Study of State Curriculum Frameworks in Mathematics and Science, Draft, 1995.

content standards, but the frameworks typically provide no strong link to the reform of state assessment programs. (Telephone interviews with mathematics and science supervisors revealed that in some states, such as California, frameworks have been used in developing new assessments, but the linkage was not specifically outlined in the framework.)

The NRC *Science Education Standards* include assessment standards in the same volume with science content and teaching standards. The assessment standards define principles for how student assessments should be designed, administered, scored, and used at classroom, district, state, or national levels. NCTM is publishing a new document on assessment standards for math.

Inconsistencies are present between framework recommendations and assessments.

In the view of the review teams, currently there are inconsistencies between framework content recommendations and state assessments. Some states with frameworks that recommend high content standards continue to require assessments that do not reinforce the standards and rely mainly on traditional, multiple-choice test items. The following are examples of states with more extensive plans for assessment reform linked to framework content: New York and Idaho have assessment reform reports; South Carolina has a policies reform plan based on new content frameworks (see Exhibits 13 and 14).

A linkage, or even "alignment," between a framework's subject content and state assessment does not necessarily indicate a reform-oriented assessment that reflects national mathematics or science standards. For example, in the past, state content guides and frameworks have been "aligned" to traditional tests that emphasized basic skills. Analysis of these kinds of tests in mathematics indicate they do not support high standards for learning (Romberg, Wilson, and Chavarria, 1990; Madaus, et. al., 1992).

State assessment policies and programs are evolving. In 1993-94, 45 states conducted mathematics student assessments, and 32 conducted science assessments. Of these, 31 states incorporate mathematics performance assessments or open-ended items, and 24 states incorporate these methods in science (Bond, Roeber, and Braskamp, 1994, annual survey of state assessment directors; Laguarda, Breckenridge, and Hightower, 1994).

Determining the degree to which framework content standards are accurately and adequately represented in the state assessment program would require a detailed analysis of each assessment instrument. More definitive criteria for measuring the degree of alignment of state content standards with student assessments should be developed to provide for further analysis.

Linkages to assessment can be assisted by performance standards.

Recent state frameworks have defined "performance indicators" or "performance expectations" as part of their content standards explanation (see Exhibit 15), but only one framework (Idaho mathematics—see Exhibit 13) in the CCSSO study includes performance standards that define two or more levels of performance or achievement in a content area (such as basic, proficient, and advanced), as envisioned by the National Council on Education Standards and Testing (1992). States such as Arizona, California, Illinois, Kentucky, Maryland, and Vermont have developed these kinds of performance and achievement levels for their assessment programs; but these levels are not included in the curriculum frameworks. Performance standards are a key step in developing student assessment programs that are closely tied to intended curriculum content. The following are examples of frameworks that are mov-

Exhibit 13 Example of Assessment Exercises

Idaho K-12 Mathematics Content Guide and Framework, (p. 56-57)

Following are example **4th Grade Performance Assessment** items.

1. How many numbers are there between 4 and 6?

    a. Describe in writing the kinds numbers between 4 and 6.
    b. List the numbers.
    c. Describe in writing how you know the numbers you find are between the two numbers.

2. Order these seven terms from most general to most specific. Polygon, rectangle, square, quadrilateral, trapezoid, parallelogram, and figure.

    a. Describe in writing each figure.
    b. Describe in writing how well you think you solved this problem.

3. The temperature was 22 degrees just 8 hours ago. Now it is 4 degrees below zero. How many degrees has the temperature changed?

    a. Has the temperature changed to warmer or colder? Explain.
    b. Draw a figure illustrating your solution.
    c. Describe how you arrive at the answers in "a" and "b."

4. Following is the cost of several items:
    A candy bar costs 50¢; a piece of bubble gum costs 5¢; a bag of M & Ms costs 75¢; one hard candy costs 2¢; one licorice costs 10¢; a ruler costs 15¢;an eraser costs 10¢; and a pen costs 45¢.

    You buy 3 items. You give the store clerk 7 dimes, and you get 3¢ change.

    a. What all could have you bought?
    b. Describe why you could have purchased several different groups of 3 items.
    c. Describe in writing how well you think you solved this problem.

IDAHO PERFORMANCE MATHEMATICS ASSESSMENT SCORING STANDARD

4– ADVANCED PROFICIENCY AT GRADE LEVEL

- Advanced understanding of situation
- Advanced communication skills in the subject area
- Demonstrates higher order thinking skills (synthesis, analysis, evaluation)
- Process is clear and appropriate
- Uses problem solving strategies effectively
- Errors are minimal or non-existent
- Solutions are correct
- Student is innovative and creative
- Works well with others when and where applicable
- Participates voluntarily in class activities when appropriate
- Able to evaluate self and adjust
- Appears willing to work equally or beyond expectations
- Takes advantage of the tools instrumental in "DOING" the work necessary to succeed

3– PROFICIENCY AT GRADE LEVEL

- Demonstrates understanding of situation
- Demonstrates effective communication skills in the subject area
- Uses higher order thinking skills (synthesis, analysis, evaluation)
- Process is adaptable
- Problem solving strategies are evident
- Some surface errors
- Solutions are defendable
- Well defined structured process
- Generally works well with others
- Participates in activities
- Demonstrates an ability to usually evaluate self
- Uses the appropriate mathematics tools effectively

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Exhibit 14 Example of Assessment Recommendation

South Carolina Mathematics Framework, (p. 110-111)

Assessment Goal

South Carolina will institute a new, improved assessment system that will exert a positive influence on mathematics education.

(1) All assessments will be aligned with the mathematical knowledge, skills, and processes expected of all students in South Carolina. When assessment is closely aligned with the curriculum, meaningful inferences can be made, and the curriculum itself becomes the standard against which an assessment is made.

(2) Assessment practices will promote the development of mathematical power for all students in South Carolina. Good assessment must provide information about what students know and can do in using mathematics in meaningful ways.

(3) A variety of effective assessment methods will be used to evaluate learning standards of mathematics education in South Carolina. The methods should be substantially *performance-based* and *criterion-referenced.*

(4) South Carolina's citizens will be better informed about mathematics assessment, assessment practices, and the uses of assessment.

- Different information needs may require different assessments and that one assessment cannot serve all needs;
- multiple sources of information lead to better informed decisions;
- traditional tests of achievement are only incomplete measures of overall knowledge and capabilities; and
- potential unfairness to an individual or a specific group of people can result if decisions are based on assessment of performance without assessment of equity of opportunity to learn.

Exhibit 15 Example of Performance Standard

Colorado, Model Content Standards for Mathematics, Science (p.S-18)

STANDARD 4:

Students understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.

This standard focuses on four major areas of student expectations related to their understanding of interactions of Earth systems and the structure and dynamics of Earth and other objects in space: Earth's composition, history, and processes that shape it; the atmosphere and processes of weather; uses and importance of water and its movement through the environment; and the structure of the solar system, dynamics of the universe, and how space is explored.

4.1 Students know the composition of Earth, its history, and the natural processes that shape it.

RATIONALE
By studying Earth, its composition, history, and the processes that shape it, students gain a better understanding of the planet on which they live. Landforms, resources, and natural events such as earthquakes, flooding, and volcanic eruptions affect the location of population centers. Life throughout geologic time has been, and continues to be, affected by changes that occur on Earth's surface.

GRADES K-4
In grades K-4, what students know and are able to do includes

- describing different types and uses of earth materials such as rocks, soil, and minerals;
- recognizing that fossils are evidence of past life;
- identifying major features of Earth's surface such as mountains, rivers, plains, hills, oceans, and plateaus;
- describing processes that change Earth's surface such as erosion, mountain building, and volcanic activity; and
- recognizing that humans are affected by natural events such as earthquakes, volcanoes, and floods.

GRADES 5-8
As students in grades 5-8 extend their knowledge, what they know and are able to do includes

- explaining and comparing how minerals and rocks form;
- explaining how fossils indicate that life has changed through time;
- simulating natural processes that shape Earth's surface such as erosion, mountain building, and volcanic activity; and

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ing states toward performance standards in mathematics or science: New York mathematics, science, and technology framework, Idaho mathematics framework, Colorado mathematics and science standards, Ohio mathematics and science frameworks, and Kentucky integrated framework. Kentucky and Ohio frameworks are written as statements of expected student performance, with sample assessments, and the content standards unfold from performance expectations.

One-half of frameworks link content to teacher professional development.

Almost half of the frameworks (18 of 40) provide recommendations or report linkages to teacher professional development. Twelve frameworks present recommendations for changes in professional development in line with subject content, and seven frameworks recommend new policies on preparation of teachers. National standards place a strong focus on changing teaching strategies and practices, as evidenced by the NCTM *Mathematics Teaching Standards* (1991) and the "Science Teaching Standards" of the draft NRC *Science Education Standards* (1994).

Curriculum developed in line with new national standards, and state frameworks based on these standards, requires complex methods of instruction, with new teacher and student roles. These new methods and roles were not suggested by earlier state curriculum guides. All of the SSI designs for reforming mathematics or science involve more intensive professional development experiences (Shields, Corcoran, and Zucker, 1994), yet not quite half of the recent frameworks draw any explicit connection between the mathematics or science content being outlined and the needs of teachers in developing their knowledge and skills to implement the content in classrooms.

Another aspect of systemic reform in many states is improving the initial preparation of teachers in mathematics and science. However, only seven (of 40) curriculum frameworks make any reference to how the content being recommended is or should be linked to the preparation that new teachers will experience. One framework (Kentucky) describes the ties between the framework and current teacher education programs or certification, and six frameworks include recommendations about the preparation of mathematics or science teachers.

Frameworks can provide a rationale for use of technology and tools in classrooms.

Less than one-third of the 40 frameworks cover any one of the other policy areas. Twelve frameworks outline current or recommended policies on selection of materials and texts, and 13 frameworks suggest how policies on the use of technology can support the content recommendations.

In the view of the review teams, frameworks should address the availability and appropriate use of high technology, such as calculators and computers, and other tools for doing mathematics and science, such as rulers, scales, mathematics manipulatives, or laboratory equipment. Statements about the need for technology and tools in the classroom can have significant funding implications for states and districts. However, state frameworks are an appropriate place for connections to be made between technology and equipment as important conditions for learning and high-quality mathematics and science for all students. As one example, the California mathematics framework discusses traditional, alternative, and recommended practices in the use of technology (see Exhibit 16).

Only six frameworks address broader issues concerning school governance and decision making, for example, the use of time and space and staff allocation. Five frameworks in science education discuss policies

Exhibit 16 Example of Use of Technology

Mathematics Framework for California Public Schools, K-12, (p. 59)

	Traditional practices	Some alternative practices	Recommended practices
Calculators ▶	Calculators are used only for a few calculator lessons and are not permitted for daily assignments and tests.	Calculators are used for calculator lessons and problem-solving lessons. In some programs students use calculators to check paper-and-pencil computations. In other programs students use calculators after paper-and-pencil algorithms are mastered. Students are not permitted to use calculators for tests.	Students have calculators continually available for use—in class, for homework assignments, and for tests. Students conduct experiments based on calculators to explore the behavior of mathematical structures.

Traditional practices	Some alternative practices	Recommended practices	
Computers and software are used for drill and practice if at all and then often in a computer lab staffed by a specialist or aide. The computer helps the teacher only as a grade book.	Computers and software are used more frequently and more often in the classroom. Students use a few imaginative pieces of software that usually focus on specific types of problems. The computer work is considered enrichment and is not connected to students' core work. Students work in groups because there are not enough computers.	Computers are available at all times. Students can use them individually or in groups. Teachers and students use more sophisticated special-purpose programs and are fluent enough with tool software—such as word processors, spreadsheets, and data bases—to use the computer to meet their particular needs. The computer is considered to be an extension of human capability and not an end in itself.	**◀ Computers and software**

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on facilities, and three frameworks address student services that would support high-quality mathematics and science. Eighteen of 40 frameworks did not present any linkages of policies to the recommendations for subject content.

Frameworks can help explain an approach to systemic reform.

A curriculum framework can speak to decision makers and the public, as well as to educators in the field. A section of the framework could lay out issues, ideas, and plans for education in the state that will help show connections between the state's standards for mathematics or science and other parts of the education system—teacher education, professional development, school facilities, student assessment and school accountability, organization of schools and use of time, selection of materials and technology, business groups, and parents and communities.

In most cases, however, other documents will be needed to adequately specify the application of content standards in these policy areas, for example, standards for teacher education that are based on the state standards for student learning. The following are examples of state frameworks that address systemic reform issues linked to subject content: The New York mathematics, science, and technology framework includes a section in the vision for change on the state systemic reform plan; the South Carolina mathematics framework describes the state policy changes that are needed to implement the framework; the Ohio science framework describes school conditions for learning needed for implementing recommended content in the classroom (see Exhibit 17).

Frameworks can assist schools in evaluating curriculum organization and resources.

State frameworks generally have the purpose of guiding local educators in developing curricula in mathematics and science. The review teams noted that frameworks can also be used to help districts and schools analyze and evaluate their current curriculum organization. For example, local teams can use the framework as the basis for reexamining the scope of elementary content across grades or the secondary course structure by enrollment patterns. Or school planning teams can use the framework to determine where they want to be with the mathematics or science curriculum in one, two, or five years, and then to plan what will be needed to get there and what decisions will need to be made and by whom, such as decisions on developing staff knowledge and skills, obtaining new curriculum materials and tools, arranging for professional development, and making better uses of time and resources.

The following are examples of frameworks used in curriculum analysis: the Nebraska mathematics and science framework has a chart for analyzing the implications of content standards for curriculum and classroom practices (to ask, "what we're really doing now vs. where we would like to be") as part of professional development for use of the state framework; the Minnesota science framework leads educators through a series of analytical questions about their curriculum; the Virginia science framework is accompanied by a science program assessment instrument for looking at the whole school; Kentucky's Volume 2 is a practical guide for how to do local analysis and planning of curriculum and how to develop strategies for instruction; California mathematics framework has a section outlining an implementation decision-making model for local educators.

Exhibit 17 Example of Framework and Systemic Reform

New York, Curriculum, Instruction, and Assessment Framework for Mathematics, Science, and Technology, (p. 10)

The new framework for mathematics, science, and technology education starts with broad statements of standards that satisfy both personal and societal needs. The standards state clearly how learning will prepare individuals to assume future adult roles. Performance indicators for elementary and intermediate grades provide feedback and guidance to make sure that students are progressing toward the standards. Assessment is based on the degree of progress that students are making toward understanding a specific area of knowledge.

In order to design an educational system that will enable students to achieve broad standards in a holistic learning environment, we need to determine the cornerstones on which our framework will sit. The new instructional structure will have many design features. To facilitate the discussion of the underlying assumptions of the new framework, four cornerstones have been identified: Content and Curriculum, Instructional Models, Authentic Assessment Techniques, and Restructuring of the Learning Environment. The educational system that is designed must be dynamic. There must be constant interaction between the broad standards and the four cornerstones, as depicted in the following view of our educational structure.

Framework Dissemination and Implementation

The state plan for implementing a curriculum framework is a critical step. A purposeful process is needed by which local educators, specialists, decision makers, and the public find out about the framework, gain an understanding of its vision and content, and determine how to use and apply the framework's recommendations to mathematics and science education in the state.

Strategies can improve the design of frameworks and related materials for intended users.

Frameworks typically state that teachers are primary intended users or audience. The review teams found that frameworks are often written and organized in a style that assumes that state or local specialists or others will mediate with further explanation, explanatory materials, or an offer of extensive technical assistance (such as the regional workshops being conducted by the Nebraska frameworks staff and committees). Some frameworks are clearly written for local curriculum development teams (such as Colorado mathematics and science, Kentucky integrated, and North Carolina science frameworks). In framework development, representatives of the intended audience(s) can help guide and try out drafts of the framework.

Curriculum frameworks have to resolve an inherent tension between length and complexity of the document and ways to make it accessible and useful to educators. The review teams noted that some frameworks provide in-depth explanations and examples, but the complexity of the document or its lack of classroom-focused ideas may discourage teachers who are learning new ways to teach at the same time they are building understanding. Detailed frameworks can also send the wrong message. For example, one framework included numerous classroom activities; but, unfortunately, some good examples were accompanied by poor examples of classroom practices.

Some states have developed several different documents to improve dissemination to educators. New Jersey is developing a broader "framework" document that will assist in implementing the completed mathematics standards document; Nebraska is developing an implementation guide, based on its framework for mathematics and science; California has a brief, compact version of the science framework; Florida has a draft teacher educator guide based on the science framework; North Carolina uses a video on the framework for professional development; Wisconsin is designing a CD-ROM version of their framework to encourage use at the local level.

States are using a variety of methods of dissemination.

CCSSO interviews with state mathematics and science supervisors for 28 state frameworks produced information on how the states are disseminating completed frameworks within their states and what steps are taken to implement frameworks through staff development. Table 11 outlines the results of these interviews. **The information on "Dissemination Targets" shows that the main target groups for dissemination across the 28 states were curriculum specialists and schools.** Aggregating across the target groups mentioned by state supervisors, the main categories for dissemination of framework copies are the following:

- Schools or school buildings—17 (of 28) frameworks
- Mathematics/science supervisors or department heads—11 frameworks
- District administrators or districts—11 frameworks

- Teachers or mathematics/science teachers—10 frameworks
- Mathematics/science associations, colleges of education, or libraries—9 frameworks

"Dissemination" was interpreted by respondents as direct distribution of a copy of the framework itself. The strategy of a majority of states in this survey appeared to be to mail a copy to each school in the state. In some cases, mathematics and science specialists or department heads in schools were specifically identified. The intent of school-based dissemination may be to encourage use and application of the framework at the school level, rather than by the individual teacher or the district.

Another group of states had a target of district specialists or administrators, and a third approach (sometimes overlapping other methods) was to provide each mathematics or science teacher with the framework.

Direct dissemination to teachers (10 states) was used mainly in smaller states, such as New Mexico, South Carolina, and Utah, with New York as a notable exception. Several states also disseminated frameworks through "networks" of mathematics and science teachers and educators, including Arkansas, Indiana, and North Carolina.

The information on the numbers of copies that were distributed show that the totals vary from 1,000 copies in Colorado (a draft version of state "mathematics and science standards" that is in review) to 350,000 copies in New York. The numbers of copies distributed are generally consistent with the dissemination targets, such as 700 schools in North Dakota; 9,000 schools and mathematics and science specialists in Florida; 33,000 schools in California; and 350,000 teachers in New York.

The information on dissemination can be compared with the "intended users" defined in frameworks (see Table 3). **The conceptual mapping of frameworks showed that 80 percent of frameworks defined teachers as a primary intended-user group, usually along with curriculum developers and planners. The targeting of dissemination shows, however, that in a majority of states, dissemination is not aimed directly toward individual teachers.** States typically disseminate frameworks to educators responsible for school or district curriculum development. It appears that many states expect the framework to influence teachers and classroom practices by the school or district applying the framework's recommendations.

Staff development has a critical role in framework dissemination and implementation.

Almost all states have offered staff development workshops covering the framework. The workshop format varied by state from meetings on increasing awareness of the framework to specific training on the implementation of the framework. In Colorado, for example, general information workshops are offered on standards-based education, as well as a workshop specifically on standards and assessment. In Nebraska, workshops are aimed specifically toward implementation of framework concepts in schools and classrooms.

Overall, workshops in 10 states provide an introduction to the framework, seven states provide training, six focus on implementation, three focus on assessment (e.g., Massachusetts—assessment *and* implementation training, Colorado—assessment and standards), and one state (New Mexico) answers individual school requests for staff development on the framework. Five of the states specified that workshops were held at a regional or district level, and four specified that workshops were held in the summer.

The interviews that produced the information on dissemination and staff development were quite short (15-20 minutes), and questions were not designed to provide details or assessment of quality of state implementation. We did not ask about other strategies for implementation of the framework, such as working with professional associations or administrator groups; nor did we ask about specific approaches unique to a state.

To adequately assess the role of curriculum frameworks in education reform within a state, future analysis should take two forms. First, researchers should evaluate how the recipients of framework dissemination in each state (enumerated previously) have used the framework—particularly the central themes, ideas, and strategies emphasized in the framework. Case studies of framework implementation in specific states are an appropriate design for further analysis of frameworks in the context of reform.

Second, we should analyze the extent to which the policy linkages mentioned in some frameworks are actually producing change in state policies regarding assessment, professional development, teacher education, materials, and other policy areas. More and more states are recommending policy linkages that would provide consistency and support for the content standards or statements outlined in the framework. A state's implementation of the framework should also be seen in other areas of education policies reflecting the standards for mathematics and science education. The policy linkages identified in this study would provide a starting point for such research.

TABLE 11

Dissemination of Selected State Curriculum Frameworks

(N = 28 Selected Recent Frameworks)

State Framework	Dissemination Targets *(from interviews conducted in July 1994*)*	# Copies Distributed *(July 1994)*	Implementation/Staff Development *(July 1994)*
Mathematics			
Arkansas	Department of Education network, teachers, and administrators.	1,500	Training guide for local curriculum. Trained regional staff to assist curriculum and assessment based on framework.
California	Mathematics agencies and schools.	10,000 initial 100,000 total	None reported specific to the framework.
Idaho	Libraries, colleges, schools, and math associations in Idaho.	5,000	Regional framework workshops.
Indiana	All schools, a network of teachers, and all school supervisors.	60,000	Summer workshops. Teachers training, teachers regional workshops.
Kansas	All schools and educators.	7,000	Trainer models and conferences.
Massachusetts	All teachers and schools.	unknown	Summer workshop overview with framework, training in its use, and assessment.
New Jersey	Mathematics associations, coalition, all public and nonpublic schools.	7,000	Regional leadership teams have been formed to pilot the workshops.
Ohio	All schools and teachers.	15,000	State, regional, and district workshops for overview of the framework.
South Carolina	All public school teachers, colleges of education, and math consultants.	50,000	Statewide resource hubs.
Texas	All schools and superintendents.	8,000	18-hour training package.
Utah	Curriculum directors, preservice institutions, teachers.	15,000	Week-long regional, districtwide workshops for core training.
Science			
California	All schools.	33,000	Workshops for overview, use of themes, and implementation.
Connecticut	All school districts, science teachers, and science supervisors.	unknown	Assessment workshop.
Florida	Schools, supervisors for curriculum development and superintendents.	9,000	Workshop including hands-on training with framework software.
Kansas	All districts and schools.	4,000	Summer workshop focusing on standards and use of the framework.
Michigan	All schools and many requests.	15,000	Review session focused on framework objectives.
Minnesota	All schools and science department heads.	10,000	Framework user workshops focusing on the framework, outcomes, and implementation.
North Carolina	Schools, SSI offices, math/science education networks, and colleges	32,000	Education institutes to train teams in the use and implementation of framework.
Ohio	County, city, and exempted village educators.	15,000	Statewide Systemic Initiative (SSI) grant trains teacher leaders

Dissemination of Selected State Curriculum Frameworks (cont.)

State Framework	Dissemination Targets (from interviews conducted in July 1994*)	# Copies Distributed (July 1994)	Implementation/Staff Development (July 1994)
Science (cont.)			
Utah	All teachers.	10,000	Workshop training in use and implementation of framework.
Virginia	All local school divisions and staff members.	100,000	Instructional workshops on framework objectives and implementation.
Combined Mathematics & Science			
Colorado	Schools, accountability committees, education, school board presidents, school districts, science community, and associations.	6,000	Workshop on standards-based and 2-day workshop on assessment and standards with step-by-step template.
Dist. of Columbia	All math/science teachers.	1,000	Teacher one-week summer institute, Principal seminars, and school-year workshops on classroom practices/ activities.
Kentucky	All districts.	3,000	Awareness summer sessions (3 hours), video broadcasts, workshops by professional organizations and regional consortia.
New Mexico	All schools and mathematics teachers.	8,000	Staff development activities held on requests by schools.
North Dakota	All school buildings.	700	Workshops conducted by professional math organizations.
Nebraska	All school buildings, to include principals and math and science chairs.	2,000	Implementation workshop training.
New York	All teachers, administrators, superintendents and math/science centers.	350,000	Awareness workshops to introduce the framework.

* **Note:** Information from interviews with state science and mathematics supervisors for 28 state frameworks, including states with Statewide Systemic Initiatives (SSI) and Eisenhower Mathematics/Science Frameworks grant states, July 1994.

Source: Council of Chief State School Officers, Study of State Curriculum Frameworks in Mathematics and Science, 1995.

Curriculum Frameworks as Resources for Mathematics and Science Reform

The CCSSO study of state curriculum frameworks in mathematics and science found that state frameworks are an active and major enterprise of state departments of education. Two-thirds of the 60 current state curriculum frameworks in mathematics and science were completed since 1990. In addition, many states are now developing new frameworks. As of fall 1994, half the states were developing or revising a curriculum framework in science; and almost half were developing or revising a framework in mathematics.

The concept of the curriculum framework is changing, and the concept varies across states. Ongoing national, state, and local efforts to improve and reform mathematics and science education are strongly linked to state frameworks. CCSSO's study results provide a summary of how frameworks are changing and the role that frameworks have in mathematics and science education reforms within states. This report provides a snapshot of what frameworks are like in 1994, but the study also reveals that frameworks are continuing to develop and change. These findings describe a moving target; further analysis should occur periodically.

Mathematics

The NCTM *Standards* (1989) are represented in all recent state mathematics frameworks. The major organizing categories, or "standards," used in recent mathematics frameworks are based on principles of the *Standards*. Recent state mathematics frameworks are typically organized by three or four grade-level blocks (e.g., K-4, 5-8, 9-12), and frameworks typically present and explain mathematics "content" as the combination of subject areas or topics (e.g., algebra, numbers, measurement) and student skills or capacities (e.g., problem solving, communication).

Science

Recent science frameworks reflect principles of organization and emphasis in the AAAS *Benchmarks* (1993) and draft NRC *Science Education Standards* (1994). These national documents are represented strongly in science frameworks completed since 1993. State science frameworks typically have a content structure that is consistent with the AAAS *Benchmarks* and NRC *Standards*; however, a number of frameworks either exclude or do not emphasize one or two key areas, such as the nature of science, the history of science, science as inquiry, and science applications.

Content Standards

State frameworks differ substantially in the level of detail provided in their content standards, or content statements. The frameworks also differ substantially in how the content statements are communicated to readers and how they are related to mathematics or science classroom practices. Recent frameworks completed by Colorado, Kentucky, Florida, California, and Massachusetts have

fewer than 15 main "standards" for mathematics or science that apply across grades K-12. Among these states, Colorado and Florida provide more detailed explanation of standards for grade blocks and content areas. Kentucky, California, and Massachusetts frameworks include extensive examples of the implementation of standards in classrooms and how they apply to teaching practices.

The expert review teams that analyzed recent frameworks concluded that the language of standards statements is critical to their effectiveness. The reviewers found that some frameworks are based on national standards, but have standards statements that are written too generally or with language that does not set high expectations for students. These frameworks are less likely to be useful in portraying the intent of high standards or in helping educators revise their curriculum and teaching practices.

The review teams also found that frameworks that extensively use lists of content topics or student skills, as opposed to full sentences or paragraphs, are less effective in communicating the intent of standards or increasing educators' understanding of standards. At the detail level, state content standards are sometimes inconsistent or do not follow through the main intent of the standard. For example, recommendations on problem-solving approaches in high school mathematics were weak in some frameworks, some frameworks did not clearly discuss the role of calculators in mathematics classrooms, and some did not effectively show connections between a content area (e.g., geometry) and developing student skills (e.g., reasoning or communicating).

Communication of Content

State frameworks are changing in purpose and structure. A much larger proportion of frameworks completed since 1990 has incorporated a variety of methods of communicating content and assisting educators with pedagogy related to content. Before 1990, few frameworks provided examples of effective classroom practices related to an area of mathematics or science content. Recent frameworks, however, suggest practices in combination with presentation of subject content. The mathematics and science content being recommended by national standards requires different methods of teaching, active roles for students, and more use of tools and materials—in essence, major changes in approaches to teaching.

States have recognized that frameworks can, and should, provide a bridge between high content standards for all students and efforts to change teaching practices. They can help educators understand, interpret, develop, and apply standards. Suggested practices, examples, and classroom vignettes are being incorporated into frameworks to help educators make connections between standards, their own curriculum and instruction, and a new vision for mathematics or science education.

Equity and Policy Linkages

Equity and policy linkages are two important elements in the analysis of state frameworks. Many of the key strategies and steps to be taken by educators and decision makers with curriculum involve improving access and opportunity to high-quality mathematics and science for groups of students that have often not had high achievement. Many of the questions about new national standards and state standards involve grouping, tracking, and differentiated curriculum in mathematics and science. A majority of recent frameworks have statements related to increasing equity and opportunity as part

of their vision for reform. Only a few frameworks completed since 1990, however, devote attention to how equity can be approached in implementing content in the curriculum. Too many frameworks are silent on findings from research, strategies for curriculum development and organization, and examples of effective practices. If the goal of frameworks is to assist local educators with implementing new approaches to mathematics and science education, many states need to provide more in-depth attention to equity and opportunity to learn.

About half of the states completing frameworks since 1990 use the framework to draw connections between subject content being recommended and state policies that are needed to support a coherent approach to mathematics or science reform. The CCSSO study shows that the role of curriculum frameworks is currently changing with regard to policy linkages, with the most recent frameworks taking a much more comprehensive approach to the relationships of mathematics/science content to student assessment, professional development, and other areas of policy.

Assessment

Several recent frameworks recommend use of multiple forms of student assessment, and several have useful examples of assessment exercises or tasks that are closely tied to mathematics or science content. Many educators currently view required state assessment programs and reporting of scores as a central function of state education departments. Several frameworks suggest directions for change in state assessments, but the role of the framework, or content standards, in developing new state assessments is generally not spelled out.

Only one state framework currently includes direct recommendations to educators on performance standards that define two or more levels of student performance in areas of content. A few frameworks developed since 1993 include statements of student "performance expectations" in mathematics or science, but specific definitions are not found for differentiating acceptable performance versus what is not acceptable. Other information available to CCSSO shows that several states have developed performance standards with defined levels for use with state assessment programs. These standards were generally developed subsequent to a mathematics or science framework.

Working Design and Methodology for Frameworks and Standards Analysis

The CCSSO study of frameworks in 1994 demonstrates that it is possible to analyze state curriculum frameworks using a standard set of analysis categories, definitions, and procedures. The study also showed that teams of experts can produce qualitative analyses of curriculum frameworks, based on consensus judgments of how well frameworks address specific purposes and issues. The study has produced useful findings on current frameworks, but it has also produced a design and methodology for further analysis of state frameworks and content standards in mathematics and science. CCSSO also views the design and methodology as applicable to other subject areas, with some specification of professional consensus on desired content areas, pedagogy, policies, and school conditions. If curriculum frameworks continue to be used by state-level education leaders to provide a bridge between national or state professional content standards and local curriculum development, teacher education, assessment, or professional development, the approach to frameworks analysis developed in this study will continue to be useful.

Notes from Tables 4, 7, 8, 9, 10

1. Several of the state documents listed are not defined by the state as a "framework," e.g., North Carolina's "standard course of study," Oklahoma's "priority academic skills," Mississippi's "curricular structure" and Colorado's "content standards."
2. Alabama (AL) also published a mathematics Implementation Guide in conjunction with the framework.
3. Utah's teaching practices are also presented in a *Teacher Resource Book*.

References

American Association for the Advancement of Science. (1993). *Benchmarks for science literacy.* New York: Oxford University Press.

American Association for the Advancement of Science. (1989). *Project 2061: Science for all Americans.* Washington, DC: Author.

Archbald, D. (1994). *On the design and purposes of state curriculum guides: A comparison of mathematics and social studies guides from four states.* New Brunswick, NJ: Rutgers University, Consortium for Policy Research in Education.

Baker, E. L., & Stites, R. (1991). *Trends in Testing in the USA. The politics of curriculum and testing.* Bristol, PA: The Falmer Press.

Blank, R. K., & Espenshade, P. (1988). *50-state analysis of education policies on science and mathematics.* Educational Evaluation and Policy Analysis, 10(4).

Blank, R. K., & Dalkilic, M. (1991). *State indicators of science and mathematics education 1990.* Washington, DC: CCSSO, State Education Assessment Center.

Blank, R. K., & Dalkilic, M. (1992). *State policies on science and mathematics education.* Washington, DC: CCSSO, State Education Assessment Center.

Blank, R. K., & Gruebel, D. (1993). *State indicators of science and mathematics education 1993, state and national trends: New indicators from the 1991-92 school year.* Washington, DC: CCSSO, State Education Assessment Center.

Bond, L. A., Roeber, E., & Braskamp, D. C. (1994). *The status of statewide student assessment programs in the United States.* Washington, DC: CCSSO; Oak Brook, IL: North Central Regional Education Laboratory.

Cantlon, D., Rushcamp, S., & Freeman, D. (1991). *The interplay between state and district guidelines for curriculum reform in elementary schools. In the politics of curriculum and testing.* Bristol, PA: The Falmer Press.

Carnegie Forum on Education and the Economy. (1986). *A nation prepared: Teachers for the 21st century. The report of the task force on teaching as a profession.* Washington, DC: Carnegie Forum on Education and the Economy.

Clune, W. H., White, P., & Patterson, J. (1989). *The implementation and effects of high school graduation requirements: First steps toward curriculum reform.* New Brunswick, NJ: Rutgers University, Center for Policy Research in Education.

Council of Chief State School Officers. (1991) *Final report: 1994 National Assessment of Educational Progress science consensus framework.* Washington, DC: CCSSO, State Education Assessment Center.

Council of Chief State School Officers. (1995). *Recommended criteria and processes for responding to state and voluntary national standards for education.* Washington, DC: Author.

Curry, B. (1992). *Using curriculum frameworks for systemic reform.* Alexandria, VA: Association for Supervision and Curriculum Development.

Educational Testing Service. (1990). *The education reform decade.* Princeton, NJ: ETS, Policy Information Center.

Firestone, W. A., Fuhrman, S. H., & Kirst, M. W. (1989). *The progress of reform: An appraisal of state education initiatives.* New Brunswick, NJ: Rutgers University, Center for Policy Research in Education.

Freeman, D. J. (1989). *State guidelines promoting teaching for understanding and thinking in elementary schools: A 50-state survey.* Educational Evaluation and Policy Analysis, 11(4).

Fuhrman, S. H., Clune, W. H., & Elmore, R. F. (1988). *Research on education reform: Lessons on the implementation of policy.* Teachers College Record, 90(2).

Fuhrman, S. H., & Massell, D. (1992, October). *Issues and strategies in systemic reform.* New Brunswick, NJ: CPRE.

Gagnon, P. (1994, Fall). *Making standards good and bringing them to the classroom.* American Educator.

Laguarda, K. G., Breckenridge, J. S., & Hightower, A. M. (1994, September). *Assessment programs in the statewide systemic initiatives (SSI) states: Using student achievement data to evaluate the SSI.* Washington, DC: Policy Studies Associates.

Massell, D. (1993). Achieving consensus: Setting the agenda for state curriculum reform" (Draft). Consortium for Policy Research in Education.

McDonnell, L. M. (1994). *Assessment policy as persuasion and regulation.* American Journal of Education, 102 (4). (Chicago: The University of Chicago).

Madaus, G. F., et. al. (1992). *Influence of testing on teaching mathematics and science in grades 4-12.* (Boston: Boston University).

Murnane, R. J., & Raizen, S. A. (Eds.). (1988). *Improving indicators of the quality of science and mathematics education in grades K-12.* Washington, DC: National Research Council, National Academy Press.

National Assessment Governing Board. (1994). *Reading framework for the 1992 and 1994 National Assessment of Educational Progress.* Washington, DC: U.S. Department of Education.

National Council on Education Standards and Testing. (1992). *Raising standards for American education.* Washington, DC: U.S. Government Printing Office.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

National Education Goals Panel. (1991). *The National Education Goals report, building a nation of learners.* Washington, DC: National Education Goals Panel.

National Education Goals Panel. (1993). *Promises to keep: Creating high standards for American students.* Washington, DC: National Education Goals Panel.

National Governors' Association. (1986). *Time for results: The governors' 1991 report on education.* Washington, DC: National Governors' Association, Center for Policy Research and Analysis.

National Research Council. (1994). *National science education standards* (Draft). Washington, DC: National Academy Press.

National Science Teachers Association. (1992). *Scope, sequence, and coordination of secondary school science. Vol. I. The content core, a guide for curriculum designers.* Washington, DC: Author.

Porter, A. C. (1994). *National standards and school improvement in the 1990s: Issues and promise.* American Journal of Education, 102(4). (Chicago: The University of Chicago).

Porter, A. C., Archbald, D. A., & Tyree, Jr., A. K. (1991). Reforming the curriculum: Will empowerment policies replace control? In *The politics of curriculum and testing.* Bristol, PA: The Falmer Press.

Robitaille, D. F., Schmidt, W. H., Raizen, S., McKnight, C., Britton, E., & Nicol, C. (1993). Curriculum frameworks for mathematics and science. Vancouver, Canada: The Third International Mathematics and Science Study

Romberg, T. A., Wilson, L., & Chavarria, S. (1990). An Examination of state and foreign tests. Madison: Center for Research on Mathematics Education, University of Wisconsin.

Shanker, A. (1994, Fall). Making standards count. American Educator.

Shields, P. M., Corcoran, T. B., & Zucker, A. A. (1994, June). Evaluation of NSF's statewide systemic initiatives (SSI) program: First-year report, Volume I: Technical report. Washington, DC: National Science Foundation.

Smith, M. S., & O'Day, J. (1991). Systemic school reform. In The politics of curriculum and testing. Philadelphia: The Falmer Press.

Sutton, J. T., Hoover, W., Larson, R., & Marble, S. (1993). Curriculum framework analysis tool, and (1993) A summary of analyzed state curriculum frameworks, (A project of the Regional Educational Laboratory Network Program). Aurora, CO: Mid-continent Regional Educational Laboratory.

Wohlstetter, P., & Mohrman, S. A. (1994). School-based management: Promise and process. New Brunswick, NJ: Rutgers University, Consortium for Policy Research in Education.

List of Abbreviations

AAAS	American Association for the Advancement of Science
CCSSO	Council of Chief State School Officers
IKE Frameworks	U.S. Department of Education Eisenhower State Mathematics and Science Curriculum Frameworks Projects (grants to 16 states)
NAEP	National Assessment of Educational Progress
NCEST	National Council on Education Standards and Testing
NCTM	National Council of Teachers of Mathematics
NEGP	National Education Goals Panel
NRC	National Research Council of the National Academy of Sciences
NSF	National Science Foundation
NSTA	National Science Teachers Association
OERI	Office of Educational Research and Improvement, U.S. Department of Education
PSA	Policy Studies Associates
SSI	Statewide Systemic Initiatives
TIMSS	Third International Mathematics and Science Study

APPENDIX A

Council of Chief State School Officers
Study of State Curriculum Frameworks in Mathematics and Science

Elements for Analyzing State Curriculum Frameworks

The Council's study of State Curriculum Frameworks was designed with advice from an expert panel. The panel also advises the U.S. Department of Education's current evaluation of the Eisenhower Science-Math Frameworks projects in 16 states, being conducted under contract to SRI International.

At the end of January 1994, an expert panel composed of state education staff, mathematics and science educators, and researchers worked for three days to identify a set of 11 "elements" for analyzing state curriculum frameworks. The elements, outlined as follows, represent the panel's collective position on the characteristics and qualities they would look for in a state framework. The elements were the result of panel discussion of quality in frameworks, review of current state frameworks, and consideration of national standards in mathematics and science.

Status of the Framework in the State

- Is the framework a stand-alone document or is it dependent on other documents?
- Is the framework being developed, or is it complete?

Vision of Science and Mathematics Education in the State

- How is the vision of science and mathematics education presented?
- What is the rationale for change?
- What version of the change process is articulated in the document?
- What are the origins of the ideas behind the vision?

Function and Intent of the Curriculum Framework (in the State)

- What is the intent of the document? Who are the audiences of the document?
- Who (what groups) initiated development of the document?
- Who was involved in the development of the document?
- What is the document expected to accomplish?

Approach of the Framework as a Policy Statement

- What features of the document are designed to enable teachers and schools to make improvements in mathematics and/or science education?
- What features of the document rely on constraints or restrictions on teachers and schools to make improvements in mathematics and/or science education?
- What decisions are left to the local level? District level? School level?
- Characterize the nature of the approach of the document (persuasive, explicative, exhortative, etc.)

Conception of the Curriculum

- How does the document describe the discipline's importance, development, and future?
- What is the document's curricular emphasis and explicit instructional strategies?
- How does the document make connections to other disciplines and the real world?

Content of Mathematics and Science Curriculum

- Does the document reflect national discipline standards? (Which ones?)
- What are the major categories or topics unique to the state? How are the discipline's boundaries drawn?
- How is the curriculum organized (strands, themes, big ideas, etc.)?
- What is the breadth and depth of the subject matter?
- How is content integrated across disciplines?
- How are performance standards or expectations communicated in the document?
- How consistent are the principles with the examples in the documents?

Presentation and Communication of the Content

- How does the document communicate its content with its audience? (Does it use exemplars? Does it rely on other documents?)
- How readable is the document? Is it appropriate for its audience?
- Are any factual errors in evidence?

Pedagogy

- What conception of learning is presented in the document?
- What conception of teaching is presented?
- How are the conceptions of learning and teaching linked and aligned?
- How are assessment and instruction linked?

Equity

- How is equity presented in the document?
- How are grouping and tracking dealt with?
- What attention is paid to the needs of traditionally underserved, underachieving, or special needs groups?
- To what extent are equity issues infused throughout the document?

Enabling Conditions

- How does the document address the school resources and organization necessary for improved achievement in mathematics and science education (materials, time, professional development, decision-making process)?
- How does the document address the necessary school district resources and community resources?
- What does the document say about the necessary family resources?

Policy Connections/Linkages

- What policy changes does the document suggest are needed? Teacher development? Assessment? Books and materials selection? Teacher preparation and certification?
- How is the curriculum framework linked to existing policies on teacher development, assessment, materials, teacher preparation, and teacher certification?

EXPERT PANEL ON ANALYSIS DESIGN FOR STATE CURRICULUM FRAMEWORKS IN MATHEMATICS AND SCIENCE

Panel Meeting, January 1994
Washington, DC

Panel Members

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Joan Baron, Student Assessment, Connecticut Department of Education
Rodger Bybee, Biological Sciences Curriculum Study, and NRC Science Education Standards
Iris Carl, past president, National Council of Teachers of Mathematics
Donald Chambers, Mathematics Education, University of Wisconsin-Madison
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APPENDIX B

Council of Chief State School Officers State Education Assessment Center

STUDY OF STATE CURRICULUM FRAMEWORKS
IN MATHEMATICS AND SCIENCE

DEFINITIONS OF CATEGORIES AND CONCEPTS
for
CONCEPTUAL MAPPING OF STATE FRAMEWORKS

May 1994

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Status of Framework

Title *Official and complete title of framework document*

Date of Document Reviewed

Status of Framework *Classify the current status in terms of one of the following three phases:* [Select one]

- **Developing or working draft:** *Document is in a pre-distribution and development phase; it is not yet disseminated for formal review beyond a limited circle of writers or experts*
- **Review draft:** *Document is a completed draft that is being formally disseminated for comment and final revisions*
- **Adopted:** Document serves as *official guidance, mandate, or policy*

Components (reported by state supervisor): *The following possible components of a state framework were listed in a CCSSO survey of states (in March 1994). A state mathematics or science supervisor indicated which of the components are included in the state's curriculum framework document(s).*

Broad goals for learning:	general expectations, purposes, or themes of instruction in the subject or K-12 education
Content standards	content knowledge and skills students are expected to know and be able to do in math or science, often by grade level
Performance standards (or outcomes):	description of the levels of proficiency to which content standards shall be attained by students
Instructional strategies:	pedagogical approaches, ideas, procedures, and processes of teaching recommended for use with curriculum
Professional development guidelines:	rationale, content, and methods of developing educators (including teachers, classroom aides, and administrators), knowledge of curriculum and instructional practices recommended by the framework
Materials, resources, or technology:	tools, texts, and materials—especially those reflecting new technologies—recommended for use with the curricula
Linkages to state testing or assessment policy:	explanation of how curriculum frameworks and standards are related to state-sponsored or mandated assessments or assessment procedures
Other:	as indicated by state's framework such as linkages between content areas

Related Documents *Key* state-designed *and disseminated documents, in addition to the framework, referenced as a component of or complement to the curriculum framework* (not *national standards documents). Indicate author(s), title, and publication date.*

Vision of Mathematics/Science in the State

A. **State's statements related to vision:** *Quote or paraphrase a theme-setting quotation from the framework's vision or mission statements, indicating the page numbers of the reference. (p. #)*

B. **Intent or Purpose of the Framework:** *Indicate which of the following concepts best describe the rationale, goals, or purpose, as stated in the framework; add any concepts the state identifies that are not described by these overarching statements.*

- Develop student knowledge and habits of mind
- Modernize and change instruction
- Design curriculum and guide instructional resource selection
- Ensure equity and access for all students
- Make or implement assessment/evaluation policy
- Involve parents, business, and other community members
- Other

C. **Major Sources:** *Major national documents or reports; other states' frameworks or reports; or other studies or reports referenced in the opening sections of the framework that establish the vision and define the conceptual foundation for science/mathematics education.*

State Context

A. **Primary Users:** *The key groups that the framework was designed to inform, assist, or advise—those expected to make most immediate and regular use of the framework to carry out their mission and primary responsibilities.*

- **Teachers:** *teachers in all subjects and for all grades or special groups; and certified support personnel such as media specialists, counselors, etc.*
- **School and district curriculum planners:** *curriculum and instructional supervisors, designers, or writers*
- **School administrators:** *administrators at school site and central office-levels*
- **Assessment developers:** *test or item authors, contractors designing test and item specifications, administrators or assessment managers*
- **Board members:** *members of district school boards and/or school-site boards or management teams*
- **Parents:** *PTA organizations, individual parents, other parent advisory or participant groups*
- **Business partners:** *business or industry partners who work in formal relationship with schools or school boards*
- **Other community constituents:** *public sector agencies, other parent or public groups working with the school system*
- **Other:** *Indicate other users/audiences not indicated above*

Secondary Users: In addition to "primary users," those other groups that will use the framework to inform policy, consider options, or gauge the overall curriculum and standards-setting policy. Include here public groups other than the immediate users listed above. Groups and category definitions are the same as above. Category definitions are the same as above.

- Teachers
- School and district curriculum planners
- School administrators
- Assessment developers
- Board members
- Parents
- Business partners
- Other community constituents
- Other: *Indicate other users/audiences not indicated above*

B. **Enabling Resources, Mandates, or State Initiatives:** *Major funding initiatives (internal or external, regulatory or advisory), supplemental financial resources, legislative or board-sponsored mandates, requirements, and supportive arrangements that advanced or contributed to the development and/or implementation of the framework. Mention here any specific decisions that enhance local resources; technology; use of school time; professional development; facilities; schedules, etc.*

- Legislative or School Board mandates, rules, or regulations
- External funding (from federal, nonprofit agencies, etc.)

C. **Key Development Activities**: *Major steps that best describe phases, events, or processes that were used in completing the current edition of the framework.*

- Expert panel(s) and/or advisory committee(s)
- Reviews and analyses of other similar or model documents
- Suggestions, ideas, exemplars from teachers, educators and subject specialists
- Teacher participation in writing and editing for the framework's text (including writing of suggested standards)
- Successive drafts were written, reviewed, and modified
- Pilot study in districts and/or classrooms
- Wide dissemination within schools and throughout communities and the state
- Other: *Indicate other users/audiences not indicated above*

Content

A. **Major Content Organizers:** *Categories or headings* that organize subject content and indicate (in **bold**) the term(s) used for the categories, e.g., strands, standards, themes, disciplines, etc. List only the broad outline, include example of detail in the sample Standards in the next section.

[Write one sentence on how each organizer is presented/written, and how grade level clusters are used. If content categories differ greatly across grade levels, separately list content clusters for each grade level or group.]

Organization by grade level or grade clusters

B. **Features:** Methods of presenting and communicating content used **regularly and throughout** the document to illustrate the recommended curriculum content or pedagogical practices.

- Vignettes: *illustrative classroom scenarios or essays that describe teaching, situating instruction in a context that demonstrates the give and take among children and their teachers and shows with considerable descriptive detail how teachers define in practice specific content areas and instructional approaches. Vignettes often include dialogue.*
- Models or examples of instructional practice: *"How to" examples of techniques or thumb nail sketches of practice. Compared with vignettes, models are shorter, more static, and they do not attempt to reflect classroom context, discourse, or exchanges that occur among teachers and students.*
- Activities and/or instructional tasks: *lists or outline of activities or tasks, reported with a minimum of detail, surrounding context, give or take, or dialogue.*
- Diagrams, graphics, photographs: *visuals used to model or illustrate the instructional activities, tools, structures, patterns, or approaches.*
- *Other unique features (ways of presenting content, etc.)*

C. **Cross-Cutting Themes:** *Concepts for organizing and implementing curriculum content that transcend framework's major content organizers, including processes, themes, attitudes, habits of mind, etc. They appear repeatedly across several components or sections of the framework, in various content areas and topics.*

Standards

Describe the state's definition and uses of content or performance standards as specified in the framework document. Provide an example of a state standard for math/science from the middle grades. The following definitions of content and performance standards are from Promises to Keep: Creating High Standards for American Students, a Report from the Technical Planning Task Force for Goals Three and Four, to the National Education Goals Panel, *November, 1993; and Council of Chief State School Officers,* State Baselines for Goals 2000 Implementation, *April, 1994.*

> **Content Standards** *specify what content knowledge and skills students will know and be able to do upon completing particular grades or courses; the content standards state clearly the knowledge and skills to be taught, and at what developmental level content is to be presented.*
>
> **Performance Standards** *specify—usually in conjunction with a method of assessment—how good is "good enough." Performance standards gauge the degree to which content standards have been attained by individuals or groups, indicating the nature of the evidence and the quality of student performance on agreed upon tasks or measurement instruments.*
>
> **Opportunity-to-Learn Standards** *are the benchmarks the state establishes to assure each student has access to the quality personnel, courses, curriculum, resources, technology, facilities, instructional time, and learning environment they need to achieve the state's content and performance standards.*

A. **Content Standards**

State defines content standards (indicate term used by the state): _____

Number of content standards listed: (indicate number) _____

> **Quote or paraphrase definition of content standards; provide page references. (p. #)**

Example of content standard (state term) for algebra/life science:

> **Quote full or partial standard. Select examples from the middle grades: in mathematics select algebra; in science select a life science topic (living things, preferably); provide page references. (p. #)**

Primary Users are expected to apply content standards as follows: [Write a one sentence summary of the expected applications of the standards. If none, so indicate]

B. State defines performance standards:

> Quote or paraphrase definition of performance standard; provide page reference. (p. #)

Example of performance standard (state term) for algebra/life science:

> Quote full or partial standard of a performance standard that is consistent with the content standard defined above. Select examples from the middle grades: in mathematics select algebra; in science select a life science topic (living things, preferably); provide page references. (p. #)

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C. **Connection between Standards and State Assessment:** *Describe current or recommended relationship between state content or performance standards and state assessments that are specified in the framework document. If the standards-state assessment connection is not discussed at all, indicate "no information." If indicated, provide the name of the State's assessment(s), the type of items expected to be used (multiple choice, performance events, portfolios, open-ended problems, etc.), the grade levels and content areas to be tested.*

D. **Opportunity-to-learn standards or strategies:**

Give *definition and provide example, if present.*

Pedagogy

The approach to teaching and learning—the instructional strategies, processes, or activities recommended, proposed, or modeled—and the means by which these ideas are presented. Pedagogy categories are based on the NCTM Curriculum and Evaluation Standards *(1989) and on the* AAAS Science For All Americans *(1989).*

Explanation of Columns:

Lists: *Items are listed or outlined with little or no detail about how pedagogical elements are to be used within classrooms or by teachers.*

Vignettes and examples: *Illustrative stories with specific examples, "how to" statements describing a story line, or portrait exploring the discourse and instructional processes among students and their teachers. This may include dialogue, thinking, and reflective practice by both teachers and students. More than one vignette or example is provided.*

Contextualized: *In many places through out the framework, pedagogy is demonstrated through lists, diagrams, pictures, and/or portraiture—text that tells the tale of events and processes in action.*

Pedagogical Practices	Recommended in lists	Vignettes & examples	Contextualized throughout framework
Constructive and active lessons			
Technological applications			
Multiple assessment strategies			
Interdisciplinary connections			
Discourse, dialogue, and argument			
Flexible uses of time and facilities			
Working with a mix of tools, manipulatives, textbooks, and resources			
Experiments and multiple solutions			
Representation, including writing, mapping, diagramming, graphing, etc.			

Definitions for Pedagogical Practices

The framework suggests, models, or describes the following pedagogical practices:

Constructive and active lessons:	students actively engage with content, materials, tools, and/or with peers to build understanding of mathematical and scientific ideas, solutions, or explanations.
Technological applications:	students use various technological tools (calculators, including those that graph, and computers) to derive mathematical and scientific solutions.
Multiple assessment strategies:	teacher observations, conferences, self-assessments, student journals; projects, experiments, constructions; writing, tasks and real-world problems to solve; formal and informal tests; oral presentations, etc.
Interdisciplinary connections:	activities and tasks suggest ways to apply mathematical and scientific thinking to model and solve problems in core disciplines (e.g. social studies, science, language arts, etc.) as well as in art, music, psychology, business, and other fields.
Discourse, dialogue, and argument:	verbal representations of the logic underlying mathematical and scientific ideas; strategies call upon students to discuss, prove their point of view, probe one another's thinking, as well as the teacher's, etc.
Flexible uses of time and facilities:	varying time blocks, classroom spaces, libraries, laboratories, etc. are suggested as resources for learning mathematics and science.
Working with a mix of tools, manipulatives, text books, and resources:	activities and tasks suggest ways to involve students in a wide range of mathematical and scientific problem solving tools and materials.
Experiments and multiple solutions:	tasks demonstrate ways that mathematics and science are incorporated into applied contexts through problem solving, experiments, and experiences that lend themselves to alternative solutions with no single "best" answer or solution strategy.
Representation, including writing mapping, diagramming, graphing, etc.:	students are encouraged to explain mathematic and science in various formats, including pictures, diagrams, spreadsheets, models, maps, etc. as well as verbally .

Policy

A. **Policy Linkages:** *Extent of alignment of framework's vision, content, standards, and pedagogy with other state education policies, or with policy decisions that are left to district or school levels; policies that enable teachers and schools to improve math/science.*

Record the linkages within one of the following two dimensions:

- Current and **existing policy links are reported** within the document.
- Policy linkages are **proposed or/and recommended,** but they are not yet regulated by statute or rule.

Framework Linkages	Existing Policy Links Are Reported	Policy Links Are Recommended
Professional development		
Assessment for external accountability		
Selecting, developing, or using materials and textbooks		
Teacher preparation and certification		
Student support services		
School governance, including organization, decision making, flexible uses of time and facilities		
Technology integration		
Involving community representatives, parents, and business leaders in planning, review, and policy making committees		
Facilities		

B. **Equity:** *Indicate the ways the framework addresses racial/ethnicity, gender equity, inclusiveness, and attentiveness to handicapping conditions in the curriculum. Framework clearly describes or illustrates state recommendation for any one equity element that is checked.*

- Rationale and vision statements: *(e.g., importance of all students learning math/science in K-12, how framework will aid this goal)*
- Vignettes, activities, and sample problems: *(e.g., examples are multi-racial/ethnic, cross-gender, and refer to education for culturally diverse, handicapped, and limited-English speaking students, and describe diverse teaching and learning situations)*

- Instructional strategies and methods: *(e.g., including content and instructional techniques that nurture the needs of students from varied backgrounds, experiences, cultures, and communities; de-tracking curriculum; involving multicultural communities in teaching and learning, etc.)*
- Materials selection and distribution: *(e.g., guidelines for materials selection reflect high standards for all groups)*
- Assessment approaches: *(e.g., strategies that are sensitive to racial/ethnic, gender difference, minimize bias, and maximize opportunities for students to demonstrate their knowledge in various ways)*
- Staff development: *(e.g., proposes strategies to reach educators with few development opportunities)*
- Teacher preparation: *(e.g., designs that prepare teachers to teach math/science content to diverse student groups)*
- Hiring practices: *(e.g., examples of incentives for increasing numbers of minority teachers and administrators)*
- Community and business involvement: *(e.g., suggested mechanisms for increasing the involvement of diverse groups)*
- Policies and recommendations: *(e.g., state policies that promote equity and inclusiveness in teaching, curriculum, assessment, hiring, etc.)*

Other Framework Components

Major sections or chapters of state framework not addressed by preceding categories.

APPENDIX C

Council of Chief State School Officers
Study of State Curriculum Frameworks in Mathematics and Science

Questions for a Qualitative Analysis of State Frameworks in Mathematics and Science[1]

I. Content of Mathematics/Science in Framework

1. Does the framework document reflect national discipline standards?

   (How? In what ways? To what extent are the "big ideas" in the national standards documents adequately covered in the framework? i.e., math: NCTM Curriculum and Evaluation Standards; science: NRC Science Standards or AAAS Benchmarks)

1a. What is the content of the framework? How is it organized? If it deviates from national standards, is there a compelling rationale?

2. How consistent are the principles for content with the examples (e.g., vignettes, instructional strategies, sample problems) in the document?

3. Will the framework's statement of content standards contribute to educators implementing national standards for math/science curriculum and instruction?

4. Does the framework provide performance standards? If so, do they clearly indicate performance standards for evaluating the state's expectations of high standards for math/science?

II. Pedagogy, Approach, Presentation, Equity

5. What conceptions of learning, and of teaching, are presented in the framework? Is the pedagogy linked to content? Is it linked to national standards?

6. What features of the document are designed to enable teachers and schools to make improvements in mathematics and/or science education?

7. Does the framework have sufficient depth of explanation to help educators understand, interpret, and apply the kind of math and science reform indicated in national standards?

8. How does the document communicate its content with its audience (e.g., use of exemplars, strategies, sample lessons/units)? How readable or accessible is the document?

9. How does the framework make connections between the discipline, curriculum, and the real world?

10. How is equity presented in the document? What attention is paid to the needs of traditionally underserved, underachieving, or special needs groups?

III. Enabling Conditions, Policy Linkages

11. Does the framework make a clear policy linkage between recommended content and state student assessments in math/science? What about linkages to district and classroom assessments?

12. How does the document address school resources and organization necessary for improved content and instruction in math/science (e.g., materials, time, professional development, decision-making)? How are district resources addressed?

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[1] based on "Elements for Analyzing State Curriculum Frameworks," CCSSO & SRI International, January 1994.

EXPERT REVIEW TEAMS FOR QUALITATIVE ANALYSIS OF STATE FRAMEWORKS

August 1994, Madison, Wisconsin

Expert reviewers

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APPENDIX D

State Curriculum Frameworks Included in Qualitative Review and Analysis

(N = 23 Selected Frameworks)*

State	Document	Year	SSI State	IKE Framework Grant
Arkansas	*Arkansas Mathematics Curriculum Framework, Draft*	1993	▲	▲
California	*Science Framework for California Public Schools, K-12*	1990		
	Mathematics Framework for California Public Schools, K-12	1992	▲	
Colorado	*Model Content Standards for Mathematics, Science (+ 4 subjects)*	1994	▲	
Connecticut	*A Guide to Curriculum Development: Science*	1991	▲	
District of Columbia	*Mathematics, Science, & Technology Framework, K-12, Draft*	1993		▲
Florida	*Science for All Students: The Florida PreK-12 Science Curriculum Framework*	1994	▲	▲
Idaho	*Idaho K-12 Mathematics Content Guide and Framework, Draft*	1994		
Indiana	*Mathematics Proficiency Guide*	1991		
Kentucky	*Transformations: Kentucky's Curriculum Frameworks (Core Subjects, Two Volumes)*	1993	▲	
Louisiana	*Louisiana Mathematics Framework, Draft*	1994	▲	▲
Massachusetts	*Massachusetts Curriculum Framework for Mathematics, Draft*	1994		
	Massachusetts Curriculum Framework for Science and Technology, Draft	1994	▲	▲
Michigan	*Michigan Essential Goals and Objectives for Science Education*	1991	▲	▲
Minnesota	*Model Learner Outcomes for Science Education*	1991		
Nebraska	*Mathematics & Science Frameworks for Nebraska Schools*	1994	▲	▲
New Jersey	*New Jersey Mathematics Standards, Draft*	1993	▲	▲
New York	*Curriculum, Instruction, and Assessment Framework for Mathematics, Science, and Technology, Draft*	1994	▲	▲
North Carolina	*Teacher Handbook, Science K-12*	1994	▲	
Ohio	*Model Competency-Based Mathematics Program*	1990		
	Science: Ohio's Model Competency-Based Program, Draft	1994	▲	
South Carolina	*Mathematics Curriculum Framework*	1993	▲	
Virginia	*Standards of Learning Objectives for Virginia Public Schools: Science*	1988	▲	

*** Note:** The 23 frameworks selected for qualitative analysis included all SSI states and IKE grant states with a completed framework plus three other recent frameworks.

Other Statewide Systemic Initiatives States (SSI States): Delaware, Georgia, Maine, Montana, New Mexico, Puerto Rico, South Dakota, Texas, Vermont.

Other U.S. Department of Education Eisenhower (IKE) State Mathematics and Science Curriculum Frameworks Grants: Alaska, Arizona, Delaware, Maine, Oregon, Rhode Island, Wisconsin.

Source: Council of Chief State School Officers, Study of State Curriculum Frameworks in Mathematics and Science, 1995.

APPENDIX E

State Mathematics and Science Education Documents Related to State Frameworks

(Documents Submitted by States to CCSSO in Addition to Frameworks Listed in Table 1)

State	Related Documents	Year
Alabama	*Mathematics for Alabama Schools, Implementation Guide for the Alabama Course of Study*	undated
Arkansas	*Mathematics I, II, III: Arkansas Public School Course Content Guide*	
	Arkansas Learner Outcomes: A General Description	
	Arkansas Public School Course Content Guide, Science	1990-91
California	*Mathematics Model Curriculum Guide, K-8*	1987
	Statement on Competencies in Mathematics Expected of Entering Freshman	1989
	A Sampler of Science Assessment	1994
Connecticut	*Connecticut's Common Core of Learning*	1987
	Challenge for Excellence: Connecticut's Plan for Elementary, Secondary, Vocational, Career, and Adult Education 1991-1995	
Florida	*Uniform Student Performance Standards for Selected Courses, 6-8, 9-12*	
	Florida Model Curriculum Project, Mathematics, Grades K-5	
	Curriculum Frameworks, Grades 6-8, 9-12, Volumes IV (Mathematics/Computer Education) VII (Science/Health) and Supplements	1990
	Science for All Educators, Draft	1994
	Blueprint 2000: A System for School Improvement and Accountability	1993
	Transition System Companion to Blueprint 2000	
	Comprehensive Plan for Improving Mathematics, Science, and Computer Education in Florida	1989
Hawaii	*Student Outcomes for the Foundation Program*	1993
	Restructuring the Curriculum	1992
	Essential Content	1993
Idaho	*A Guide to Science Curriculum Development*	1980
	Secondary Biology Course of Study; Secondary Earth Science Course of Study	1985
	Philosophy of Science Education	
	Assessment Plan	1994
Kansas	*Kansas Quality Performance Accreditation Outcomes*	
	A National Model of Excellence	1990
Kentucky	*Kentucky's Mathematics Framework*	1989
	Science Skills Continuum	1988

State Mathematics and Science Education Documents Related to State Frameworks (cont.)

State	Related Document	Date
Louisiana	*Mathematics Curriculum Guide, Grades K-8; Algebra I Curriculum Guide*	
	K-5 Science Curriculum Guide; Curriculum Guides for Physical Science (Grade 6) and Life Science/Ecology (7); Energy Conservation Lab Manual (Grades K-8)	1991
	Biology I Curriculum Guide	1988
Maine	*Core of Learning*	1990
Maryland	*Mathematics, Reading, Writing/Language Usage, Social Studies and Science for Maryland Performance Assessment Program*	1990
Massachusetts	*PALMS (Partnership Advancing Learning of Mathematics and Science) Principles for Learning and Teaching*	1992
	Commission of Common Core Learning	
Michigan	*Model Core Curriculum Outcomes and Position Statement on Core Curriculum*	1991
Minnesota	*Mathematics Framework Outline*	
	Mission Statement for Public Education	
	Model Learner Outcomes for Gifted and Talented Learners	1990
Missouri	*Core Competencies and Key Skills for Missouri Schools, 7-10*	1991
Nebraska	*High Performance Learning Model*	
New Hampshire	*Standards for Approval of New Hampshire Public High Schools, 9-12*	
New Jersey	*New Jersey's Core Course Proficiencies in Mathematics*	1990
	Identification of the 8th-Grade Skills in Mathematics	1990
New Mexico	*Success for ALL Students: Standards for Excellence in New Mexico's Schools*	1993
	Your Educational Standards (YES) for Student Success	1993
	Consolidating Inititatives for Tomorrow's Education (CITE)	1992
New York	*Three Year Sequence for High School Mathematics, Course I, II, and III*	1989
	Learning-Centered Curriculum and Assessment for New York State	1993
	A New Compact for Learning	1991
	Science Syllabi: Blocks A, B, C, D, E, F, G, H, I, and J	1990
	Unified Science, Solving Problems in Science, Technology, and Society	undated
	Regents Syllabus: Biology, Chemistry, Physics, Earth Science	1985
	Elementary Science Supplement to the Syllabus, Levels I and II	1991
	General Biology Syllabus	1986
Ohio	*Glossary of Mathematical Terms from Ohio's Model Competency-Based Mathematics Program*	
	Preparing Ohio's Learners for the Twenty-First Century: Pre-K-12 Performance-Based Standards	
	Ohio Proficiency Outcomes	

State	Cited Document	Year
Oklahoma	*Oklahoma Expected Learner Outcomes for Mathematics, Draft*	
	Suggested Learner Outcomes: Science	1988
Oregon	*A Focus on Science Concepts, Science Concept Working Papers*	1989
South Carolina	*What Work Requires of Schools*	1992
	Using Curriculum Frameworks for Systemic Reform	
Tennessee	*Goals of Education in Tennessee, Draft*	
Texas	*Guidelines for Teaching: Calculus, Computer Mathematics I, Geometry, Grade 6*	
	Guidelines for Teaching Grade 6 Mathematics	
Utah	*Elementary Science Teacher Resource Book*	1994
	Performance Assessments, Grades 1-6, Grades 7-12	1994, 1995
	Criterion Referenced Test, Grades K-6, Draft	1996
	Instructional Templates, Grades 7-12; Criterion Referenced Test, Grades 7-12 (planned)	1997, 1998
Vermont	*Common Core of Learning*	
Virginia	*Program Goals, Program Objectives, and Learner Objectives for K-12 Science*	
	Science Education Program Assessment Models	
West Virginia	*West Virginia Mathematics Goals: An Overview*	1992

Source: Council of Chief State School Officers, Study of State Curriculum Frameworks in Mathematics and Science, 1995.

APPENDIX F

Sample Vignettes
New Jersey Mathematics Standards (pp. 41-43)

Product and Process

The students:

Mr. Marshall had assigned the following problem from the New Jersey Early Warning Test as a homework assignment for his fourth grade class:

> Use each of the digits 3, 4, 5, 6, 7, and 8 once and only once to form three-digit numbers that will give the largest possible sum when they are added. Show your work.
> Is more than one answer possible? Explain your answer.

are asked to respond to open-ended questions and present and defend their solutions.

The students were to solve the problem and match their response with that of Tilly Tester to see if they agree or disagree with Tilly's response and explain why.

are asked to analyze problems for reasonableness of results and to diagnose errors.

As the math class begins, Mr. Marshall allows the students to work in the cooperative learning groups which they have been working with this month to compare the results of their homework assignment. Mr. Marshall visits each group noting who has completed the assignment as well as the direction of the discussion for each group. Homework assignments are important and students are given credit for homework. Strategies such as displaying answers on the overhead projector and working in cooperative learning groups are used to ensure that homework review is no more than 5 to 10 minutes.

work cooperatively to assess their own and each other's work.

Mr. Marshall then asks the students to show the level of their agreement with Tilly's response on a 0-5 scale, with 0 signifying disagreement and 5 signifying total agreement. Most students raise 4 or 5 fingers, and the discussion then focuses on how Tilly's answer could be improved. One group notes that Tilly should

are willing to take a position without the fear of being incorrect.

have added each pair of numbers and shown the sum for each, while another group explains that Tilly could have also changed the hundreds place to get 754+863 and 763+854.

The students:

At this point, Mr. Marshall discusses Tilly's understanding of place value and uses the opportunity to summarize the students' responses and lead into the objective of the day which focuses on place value and multiplication.

use their knowledge of numeration to help solve problems.

"Let's work on multiplication today, and to get started, let's do some mental math with multiplication. On the back of your homework, number 1 to 10. Write the answers only for my mental math flashcards."

use mental math regularly throughout the curriculum.

Individually, the students write answers for 8000x3, 6000x7+50, 300x7, etc. After the ten problems, Mr. Marshall has the students exchange papers, and they correct and discuss the answers. The papers are collected, and Mr. Marshall poses the following problem for his students:

demonstrate their understanding of mathematical concepts in a variety of ways, each of which provides valuable assessment information to the teacher.

> Use four of these five digits and construct the multiplication problem that gives the greatest product: 1, 3, 5, 7, 9

Before allowing the students to start work on the problem, he asks them to estimate what the largest product obtained in this manner might be. Students offer estimates ranging from 3000 to 10,000 and provide explanations for their guesses. When allowed to, the class works in their cooperative learning groups. Calculators are available, and some students start guessing and checking with their calculators.

are encouraged to estimate solutions before actually determining answers.

use calculators to aid in the problem-solving process.

One group begins to discuss which digits to use, wondering whether there would be a reason not to use the four largest digits. Another group is discussing whether a 2-by-2 or a 1-by-3 arrangement would be the best for getting a large product, an aspect of the problem that some groups have completely missed. Most of the groups get around to trying out sample problems of a variety of sorts to get some parameters worked out. Toward the end of the class session, the groups share the specific answers they have come up with. The three examples that are suggested are:

using mathematical reasoning to formulate strategies and solutions.

753	93	953
x 9	x 75	x 7
6777	6975	6671

It is clear to everyone that the 2-by-2 digit problem is the one with the greatest product, but Mr. Marshall is looking for some generalizations that can be made. He points out that none of the groups used the digit "1" in their examples. *Can the lowest digit always be ruled out?* He asks the groups that arrived at the 2-digit problem to explain how they decided where to put the individual digits. *Does it matter where they were placed? Where does the largest one go? The smallest? Do you think it would always work that way regardless of what the individual digits were? How can you check?* The students reflexively pick up their calculators and begin to formulate other versions of the problem that use other digits and to check which arrangements of the digits give the largest product. One student asks his partners what they think would happen if two or three digits were the same.

The students:

approach numerical operations from a holistic point of view rather than only through paper-and-pencil manipulation.

For homework, Mr. Marshall asks the students to use the same five digits, but to find the smallest possible product. They are then to write a paragraph describing their solution and the reasoning they used to show it is, indeed, the smallest product. Specifically, they are to consider the question: *Can you just turn your thinking about the way you got the largest product upside down and use it to get the smallest product?*

write paragraphs describing and justifying their positions.

Cheche Konnen: Scientific Sense-Making in Education

Cheche Konnen is the name that was given to an innovative urban science and mathematics program to demonstrates the power of a sense-making approach for language minority students. The project began in 1988 in Cambridge, at the Graham and Parks Alternative Public School (K-8) in a Haitian bilingual 7th an 8th grade class, and a multilingual, basic skills high school class. It has since expanded to Haitian Creole and two-way Spanish-English bilingual classes in grades 4-8.

In Haitian Creole, Cheche Konnen means search for knowledge. In Cheche Konnen what students think is at the center of their activity. They explore their own questions, design studies, collect, analyze and interpret data, build and argue theories, and evaluate evidence. Investigations are interdisciplinary; science, mathematics and language (talk, reading and writing) are linked, and recognized as essential tools of scientific inquiry. Through this approach, language minority students learn to think, talk, and act scientifically. Language mediates their learning in powerful ways.

In their Water Taste Test investigation, for example, students used both Haitian Creole and English to construct scientific meaning and communicate their understanding. Using Haitian Creole, they designed their studies, interpreted data, and argued theories. Using English they collected data from their mainstream peers, read standards for interpreting test results, and reported their findings.

The students were often isolated from the mainstream school community. However, as they conducted their investigations mainstream peers began to see them as doing something important and as experts. Their teachers also took notice of them. Most important, the students developed confidence in their abilities and took a more critical stance to knowledge.

Their teacher, Josiane Hudicourt Barnes, characterized the changes she observed in this way: "I think that the kids' way of seeing the world, the way they think in general, has changed because they feel more comfortable learning on their own, investigating questions, thinking about questions, making them clearer, and finding out answers whether from books or from experimentation. And most of all, I feel that they have made a step towards being critical about what people say to them...They are learning to find out for themselves and not listen to everything that they hear."

Adapted from Massachusetts Department of Education, *Common Competencies: The promise of linguistic/cultural diversity*,1990, pp. 30–31.

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